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Gumption

"HE HAS such a way of getting things done." I knew the man that was referred to in this remark that I overheard. He was not a big, impressive, authoritative fellow; he was not of the busy, bustling, bossing kind, but when he took hold of a thing it seemed to go.

In the first place he had a clean-cut conception of the thing that had to be done, of the purpose to be accomplished, and he had an unassertive but well-grounded confidence in his ability to do it. He quietly looked over the means at hand, planned out the process or the initial stages of it, and set things in motion.

Perhaps he did not always do things in just the cheapest and most efficient way, but he got them done. If a man stopped and debated with himself at every street crossing whether he had better go one way or another, he might pick a little better route than the one who kept on going in the right general direction, but the one who kept moving would get there first.

While one man would be plaguing his superior with discussions about details that the superior would like to be rid of and holding conferences and getting opinions and trying to trim things to the best liking of those to whom he is responsible, the other would have won the highest and best regard of those for whom he was working by turning over a completed job, which is the thing the executive wanted most when he set him at it.

There is a story, old but apropos, of an old engineer in the Civil War who was told to build a bridge across a stream. Somewhat before the appointed time the general asked him if he had received the drawings, and he replied that he "hadn't seen no pictures," but the bridge was up.

Some men really act as though they thought there was as much in getting rid of a job as there was in doing it. At any rate they dally along and spend as much time and thought in thinking up reasons why it could not be done as it would have taken to do it.

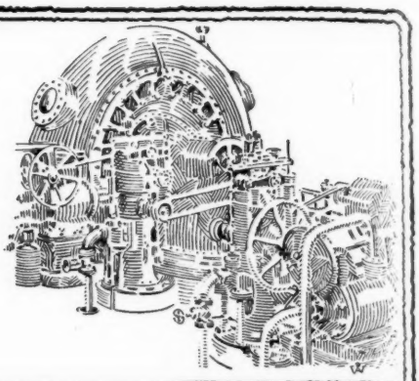
Some men are capable of nothing more than a simple repetitive process. They can do one thing and from long practice can do it well. Other men cannot work on a repetitive job more than a short time before their wits are scheming out a short cut.

I have a friend who was brought up on a farm. One morning his father set him to work to sort a huge pile of potatoes. But as he sorted, he dreamed out a machine through which those potatoes could be run and come out in nice little heaps of various sizes. When his father came back, the boy was very busy sawing up some of his nice hay poles, but the number of potatoes that had been sorted was insignificant.

The world of business and of industry is bidding high for the man with gumption, the man who can carry the message to Garcia, the man who can see what is to be done and get it over.

F. R. Low

Safeguarding Workmen in Hydro-Electric Stations



by

Ralph Brown*

IN ANY generating station it is necessary or advisable occasionally or regularly, to take apparatus or equipment out of service for inspection or repairs. It has been observed that the methods employed to insure the safety of men working on station equipment and transmission lines differ to such an extent that a satisfactory system is worthy of detailed description. The method herein described is closely patterned after that originated at the Holtwood Station of the Pennsylvania Water and Power Company.

In order that all who are concerned with station operation or maintenance may be able to understand thoroughly the safety measures devised for the protection of men and equipment, detailed safety rules have been prepared and new employees are not permitted to undertake any work until they are familiar with the safety rules that concern them. First, all those concerned with operation must understand that all station equipment not covered by a safety card is available for instant use and that equipment protected by a safety card or safety signs must not be operated under any circumstances whatsoever. Furthermore, operators only are permitted to operate equipment, maintenance men, except under special arrangements, being allowed to handle only equipment on which they are reported.

For the guidance of the operators a sheet giving the names of the workmen opposite the equipment that each individual is known to be fully qualified to work on, is posted in a convenient location, and in case of doubt this qualification sheet is referred to before a safety card is issued. Special card indexes are also provided, indicating the proper locations of all safety signs, grounds and safety chains required to afford protection to men working on any equipment. Since safety signs, grounds, etc., must be placed only at specified points, it is evident that such equipment as motors, switches, pumps, valves and circuits must be suitably designated and this designation always adhered to. In order to co-ordinate, whenever possible, all work to be done on equipment, arrangements for taking out of service major equipment, such as generating units, main transformers, exciter sets and transmission lines are made in advance when possible. The data pertaining to taking such equipment out of service for the issuance of safety cards are posted on an equipment clearance sheet. By consulting this sheet, which designates the equipment to be taken out of service, time available for workmen, nature of the work to be done, names of the men to be given safety cards, and time the equipment must be available for service, the operator is enabled to schedule his work to the best advantage.

An important feature of this safety system is the use of individual workman's tags, which are made of thin gray fiber, lettered with the names of those who may be reported on equipment. Twelve tags are required

*The Great Western Power Company.

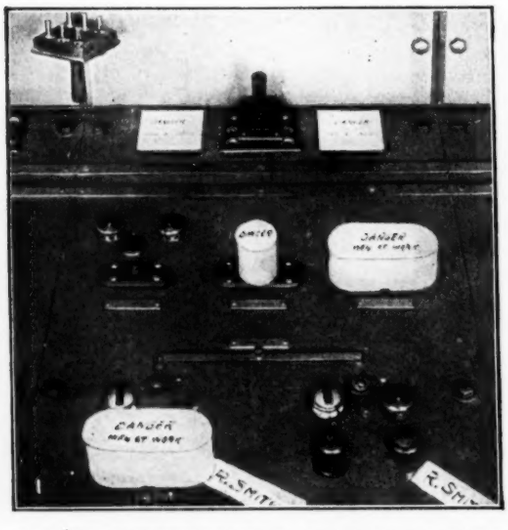


FIG. 1—SAFETY COVERS AND SAFETY CARD ON GENERATOR CONTROL

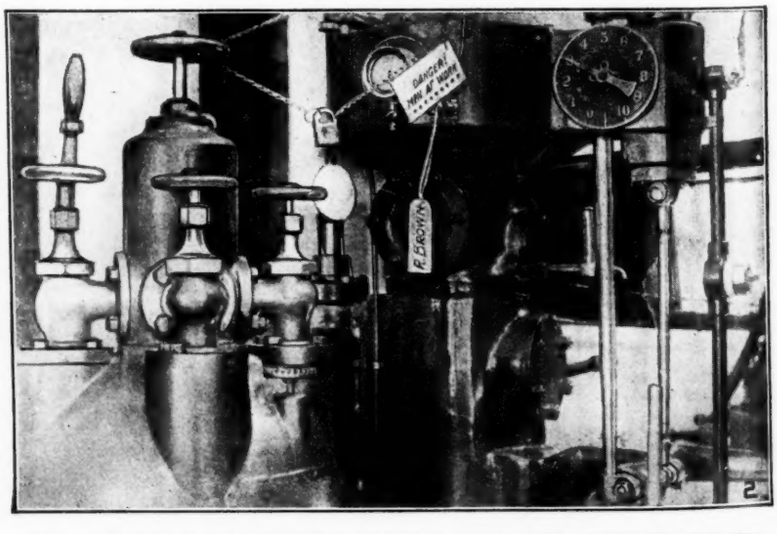


FIG. 2—SAFETY CHAIN WITH DANGER SIGN ATTACHED TO WATER-WHEEL GOVERNOR AND HAND CONTROL WHEEL

for each workman, who, after obtaining a safety card, personally attaches his tag to each safety sign placed by the operator for his protection. Just before reporting clear, the workman personally removes all his tags, and the equipment is not considered available for service until all workmen's tags have been removed. Since linemen work outside the station, operators attach their tags to the safety signs and remove them when they report clear, by telephone or otherwise. All these safety devices are kept in suitable cabinets located conveniently near the equipment on which they are to be used; that is, signs and safety chains to be used on hydraulic equipment will be found in the generator room, while signs and grounding cables used on electrical equipment are kept in the busrooms. Particular care is exercised to keep all safety devices in their respective cabinets when not in use, so that they are never in evidence except for protective purposes.

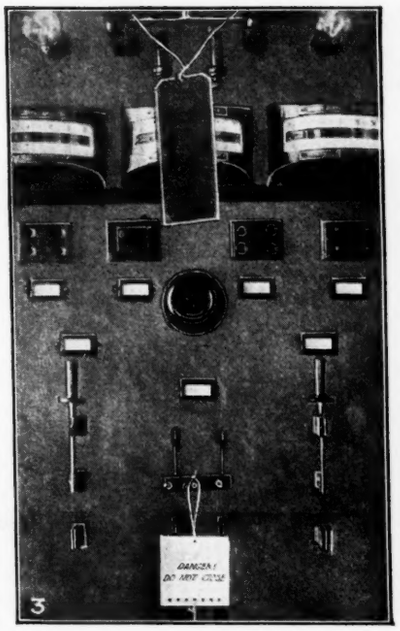


FIG. 3—SAFETY CARD ATTACHED TO CIRCUIT BREAKER AND DANGER SIGN ON SWITCH

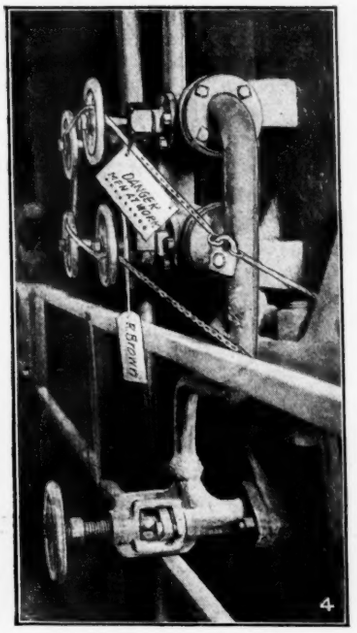


FIG. 4—CONTROL VALVES OF PENSTOCK VALVE LOCKED AND TAGGED

Safety signs are made of fiber, wood or transite of different dimensions, painted red and lettered in black to apply particularly to the points where used. Signs placed at open disconnectors are lettered "DANGER! MEN ON CIRCUIT," and those used on headgates read "DANGER! MEN AT WORK." The appearance of all lettering is made as uniform as the different sizes of signs will permit. Safety covers are made of fiber or hardwood and are used to cover control-switch buttons or handles. Steel safety chains, provided with brass padlocks, are used to lock operating levers and handwheels in safe positions, and a small metal safety sign, suitably lettered, is permanently attached to each chain.

Before a safety card is issued, the operators make the equipment to which it applies absolutely safe to work on by complying with the safety rules. For example, if work is to be done on a 220-volt circuit connected to the bus through a knife switch and fuses, the safety card is attached to the open knife switch, and a safety sign is attached to the fuse clips, from which the fuses are removed, and placed nearby. Fiber guards are used in all locations where a possibility exists of a switch making contact due to gravity, and fiber covers or plugs are used to prevent the possibility of apparatus being made alive through synchronizing of voltmeter connections. Governor and hand-control valves are chained and locked to prevent movement of turbine gates while men are working on or near them, and to keep the gate opening at the specified value. Motor-operated oil switches are placed in the open-neutral position by the operator (that position to which the oil-switch mechanism will be returned from the closed position by fuse removed), and the springs with the motor solenoid-operated switches are placed in the open position with the control fuses removed. It is highly important that such apparatus be made inoperative before being closely approached, as serious injury is liable to be caused by the unexpected operation of an oil switch.

The practice of grounding dead conductors the normal voltage of which exceeds 250 volts is followed, and safety cards are not issued until conductors are grounded. Transmission lines are grounded at each end, and by the patrolman after he has been reported on the line and has tested it for potential by grounding one end of a suitable length of No. 28 copper wire on the tower, fastening the other end to a pair of pliers or similar small object, and, standing at a safe distance in anticipation of a possible arc, throwing the pliers over the line conductors, thereby short-circuiting and grounding them.

The safety card, Figs. 6 and 7, is a printed form on thin red flexible cardboard. The name of the workman to whom the card is issued, the nature of the work to be done, time reported on, etc., appear on the front, while on the rear the locations of the safety signs are noted. Safety cards are numbered serially beginning with 1 for each station, and entries are made thereon in black ink. These cards are issued only in the case of workmen employed in or near the station, on the personal request of, and to the workmen in whose names the cards are issued. Where a

PROPER protection of workmen in power plants is something that it is difficult to over-emphasize. Lack of such precaution jeopardizes not only the lives of those who are responsible for plant maintenance and operation, but also the equipment and the service rendered by the plant. In this article the author gives the details of a plan that has been adopted with a high degree of satisfaction in the protection of workmen and increased operating efficiency. Although this system has been worked out especially for a large hydro-electric station, it could be easily modified to apply to steam plants. Operators of small hydro-electric or steam-electric stations will also find many suggestions that will serve a good purpose in their plants.

number of men are working under the immediate supervision of a foreman, the safety card is issued to the foreman, who will then be responsible for the safety of each individual under his charge. Patrolmen are reported on transmission lines over the telephone.

Attached to, and forming the lower part of the safety card, is the workman's stub, on the front of which appears the name of the workman, designation of equipment, etc., while brief instructions appear on the rear. Excepting in the case of patrolmen the stub is given to the workman when he is reported on the equipment, and when his work is completed and he is clear of the equipment, the workman signs and personally hands the

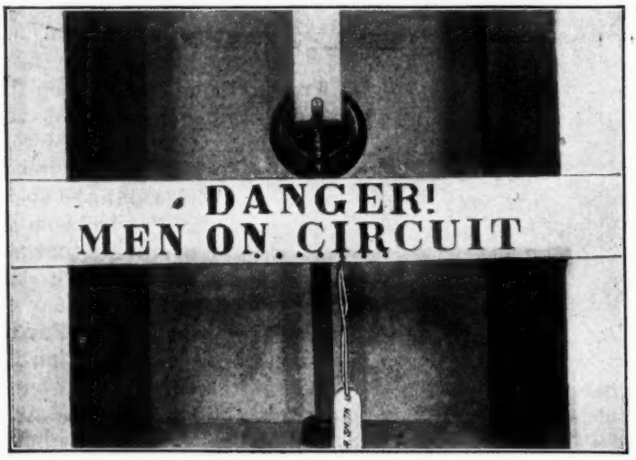


FIG. 5—DANGER SIGN PLACED BELOW OPEN DISCONNECTOR

stub to the operator. A patrolman's stub is placed with the corresponding safety card, and after he reports clear over the telephone, the operator signs the patrolman's name, followed by his own. A workman cannot transfer his stub to another under any circumstances.

After receiving the workman's stub, the workman makes an inspection to assure himself that switches, valves, etc., are in their proper positions, that the apparatus is grounded, that safety signs are properly placed for his protection, and observes the operator touch dead electrical conductors before proceeding with his work.

When a workman is reported on equipment, the fact is noted in the logbook with red ink, as follows: "8:41 a.m., R. Smith reported on No. 2 unit No. 846. 4:10 p.m." The number, 846 is the serial number of the safety card. When the workman reports clear, entry is made in the logbook in black ink, as follows: "4:10 p.m., R. Smith reported clear of No. 2 unit." The time, 4:10 p.m., is also entered at the extreme right of the red-ink entry, in black ink, as shown.

Operators are required to know at all times what, if any, apparatus or equipment is covered by a safety card, and although such information will be found in the logbook, a so-called safety-card record, Fig. 8, is used as a check on equipment that is out of service for workmen. This form is made of yellow cardboard, on the front of which is noted the designation of the equipment, numbers of all safety cards issued thereon, time ready for issuance of first safety card, and time finally available for service. A safety-card record is filled out when a safety card is issued on any equipment and placed, for quick reference, in a metal holder near the main control board. When the equipment is ready for service, this card is removed.

In order to indicate clearly what apparatus is grounded for protective purposes, a ground card, Fig. 9, made of white cardboard, is filled out for each ground applied. Since a number of men may be reported on apparatus protected by one ground, the numbers of their respective safety cards are entered, as issued, on the ground card and crossed out as each workman reports clear. The ground cannot be removed until the workmen's stubs concerned have been returned to the operator. On the backs of the safety-card record and ground card appear brief instructions indicating their respective purposes.

In order to make clear the uses and the locations of safety signs, chains, etc., examples of clearing apparatus will be given. Before work could be done on a 220-volt motor-driven centrifugal pump, the safety card and signs would be placed as indicated:

1. Attach safety card to open motor-circuit feed switch.
2. Place sign at fuse clips, after removing fuses.
3. Place sign on motor starter.
4. Place sign on closed pump-suction valve.
5. Place sign on closed discharge valve.
6. Fill out, and place safety-card record in holder.
7. Workman is given workman's stub.

If work were to be done on a bank of transformers, safety signs and grounds, if required, would be placed as follows:

1. Attach safety card to low-tension oil-switch control switch.
2. Place safety cover over high-tension oil-switch control switch.
3. Place fiber plug in each synchronizing receptacle, if used.
4. Place sign on the open bus-side disconnectors of the low-tension oil switch.
5. Place sign on the open bus-side disconnectors of the high-tension oil switch.
6. Ground and short-circuit the low-tension winding (if the normal potential exceeds 250 volts) and place corresponding ground card with safety card.
7. Ground and short-circuit the high-tension winding and place the corresponding ground card at the high-tension oil-switch control switch.
8. Fill out the safety-card record and place in holder.
9. Workman is given workman's stub.

If work were to be done on the winding of a water-wheel-driven, double-overhung generating unit, the workmen would be protected by signs, etc., placed as indicated:

1. Attach safety card to governor-control switch on control board.
2. Place sign at governor-control fuse clips, with fuses removed.
3. Place safety covers over front and rear bus generator oil-switch control switches.
4. Place fiber plugs in each synchronizing receptacle.
5. Place safety cover over field circuit-breaker control switch.
6. Place signs on the open bus-side generator oil-switch disconnectors.
7. Place sign on open field switch.
8. Lock each penstock gate valve to its corresponding by-pass valve by using safety chain. Both valves to be in closed position.

9. Lock governor and hand-control wheels at 30 per cent nozzle opening. Valves to governor and hand control to be closed.

The nozzles should be locked in the 30 per cent open position to make it convenient to inspect the nozzle and needle and to prevent, if the relief valve were closed, the building up of pressure back of the closed nozzle, due to leakage through the penstock valve. If, through some mischance, the nozzle were opened with full pressure existing between it and the penstock valve, the sudden rush of water might result in injury to men within the wheel housing. If the nozzle is locked partly open, pressure cannot build up back of it, and the needle, etc., can be inspected for wear without changing its position.

10. Lock relief valves in open position.

11. Ground and short-circuit the generator and place the ground card at the oil-switch control switch.

12. Workman is given workman's stub.

After an inspection indicates that equipment is in readiness for work to begin, the operator fills out a safety card, safety-card record, and ground card if required.

Standardized conversations are followed when reporting men on or clear of apparatus, and if a workman were to be reported on a generator, a conversation similar to the following would ensue: Operator: "No. 2 generator is out of service, grounded and ready for you to work on." Workman: "No. 2 generator is out of service, grounded and ready for me to work on." Operator: "Right. You are reported on No. 2 generator at 8:41 a.m." Workman: "I am reported on No. 2 generator at 8:41 a.m." Operator: "Right."

The operator next reports the workman on No. 2 gen-

SAFETY CARD

----------Station.

Date----------19--- No.----------

MEN AT WORK
DO NOT OPERATE

Mr.----------

IS REPORTED ON

Reported on---A.M. P.M. ---------- 19

Expects to clear --- A.M. P.M. _____ 19

Work being done ----------

---

by ----------
Operator

REPORTED CLEAR

Reported clear----A.M. P.M. ----------19

by ----------
Operator

WORKMAN'S STUB

----------19---. No. ----------

Mr. ----------

IS REPORTED ON

---

which has been made safe to work on. You will be Reported Clear when you sign this card, and return it to the operator. Apparatus must be available for service at

----------P.M.----------19

I am clear of the apparatus named above, and same is ready for service so far as my work is concerned.

(front) Signature

FIG. 6

LOCATIONS OF SAFETY SIGNS

1----------
2----------
3----------
4----------
5----------
6----------
7----------
8----------
9----------
10----------
11----------
12----------
13----------
14----------

INSTRUCTIONS

The operator will accompany the workman to the apparatus designated on this card, and shall be the first person to touch any conductors to be worked on. The workman shall make a thorough inspection to determine if the necessary safety measures have been taken to insure his protection before proceeding with the work.

The person to whom this card is issued is responsible for the safety of the men working under his supervision on the apparatus protected by this card.

(rear)

FIG. 7

SAFETY-CARD RECORD

----------Station

----------Date

----------is out of service

for men working under safety cards Nos.----------

Work being done ----------

Taken out of service ---- A.M. P.M.----------19----

Available for service --- A.M. P.M.----------19----

by----------
Operator

FIG. 8

INSTRUCTIONS

The operator will fill out one of these cards for each piece of apparatus on which a safety card is issued.

Note on front hereof the numbers of all safety cards issued on equipment to which this card applies, and cross out numbers as workmen report clear.

When last safety card is removed, remove this card, and return to office.

GROUND CARD

----------Station

----------19---No----------

----------is grounded

This ground has been applied to insure the safety of those working under safety cards numbered

---

---

by ----------
Operator

FIG. 9

INSTRUCTIONS

Fill out one of these cards for each ground applied, and place in conspicuous position on apparatus grounded.

Note hereon number of each safety card issued on apparatus grounded.

Cross off each safety card number when signed workman's stub is returned.

Remove this card when ground is removed, and send to office with corresponding safety cards.

FIGS. 6 TO 9—SAFETY CARD, SAFETY-CARD RECORD AND GROUND CARD FORMS

Figs. 6 and 7—Front and back of safety card respectively, which is printed on red cardboard. This card is perforated so that the workman's stub can be easily detached from the upper section. The form for recording the "Location of Safety Signs" is printed on the back of the safety card proper, and the "Instructions" are placed on the back of the workman's stub. Fig. 8—Form for front and back of "Safety-Card Record," the "Instructions" being printed on the back of the card, which is yellow in color. Fig. 9—Form for front and back of "Ground Card" the "Instructions" being printed on the back of the card, which is white in color. All cards are 3¼ in. wide and long enough to contain the different forms.

erator in the logbook, hands him the workman's stub and accompanies him to No. 2 generator. After inspecting the gate valves, switches, disconnectors, governors, safety signs and grounds and finding them as specified in the safety rules, the workman attaches his tag to each safety sign and proceeds with the work.

After the work is completed, the workman removes his tags, signs his stub and reports to the operator. A conversation similar to the following should then ensue; Workman: "I am clear of No. 2 generator, which is ready for service so far as my work is concerned." Operator: "You are clear of No. 2 generator which is ready for service so far as your work is concerned." Workman: "Right." Operator: "You are reported clear of No. 2 generator at 4:10 p.m." Workman: "I am reported clear of No. 2 generator at 4:10 p.m." Operator: "Right."

After making a brief inspection of No. 2 generator to be certain that no tools, extension cords, etc., have been overlooked, the operator removes the grounds, safety chains and signs, provided that all the workman's tags have been removed, and reports him clear in the logbook. The ground tag is removed after the grounds have been removed from the generator, and the safety-card record is then removed from the holder. No. 2 generator can now be returned to service.

All conversations concerning the reporting of workmen on or clear of apparatus must be explicit, so that there can be no possibility of any misunderstanding, and designations of apparatus should be such as will tend toward the avoidance of mistakes. Because some operators are inclined to assume that standardized conversations pertaining to the safety of men are a form of useless "red tape," and because there is an ever-present tendency for laziness and carelessness to interfere with the correct utilization of safety devices, this phase of operation can hardly be too closely supervised in any station.

Bearings and Bearing Metals

By Herbert B. Trix

Bearings and bearing metals do not appear to have received the attention they deserve from either the designing or the operating engineer, in view of their extensive use and the tremendous and continual expenditure for maintenance, as well as loss in production due to breakdowns in machinery and equipment as a result of bearing troubles. This is largely due to the fact that comparatively little information is available which is of direct value to the engineer in the selection of metal bearing alloys, and also due to the fact that the efficiency of bearing metals is not solely a question of metallurgy, but is also one of mechanical engineering, of physical chemistry and of lubrication.

Adequate testing of bearing metals is most difficult. As a result, bearing troubles have been accepted as a necessary evil in industry, and but little change or improvement in bearing materials has taken place for several years. It has often been assumed that the harder the material as examined by the customary hardness tests and the higher the tensile strength it possessed, the longer it would wear and the more suitable it would be for bearing properties, and for that reason the tendency in bearings and bearing metals other than the babbitt type, has been toward the phosphor bronzes and other extremely hard and tough alloys. It is now being realized, however, that there is no relation between the property we call hardness of metal and its wear-resistance qualities, and that the ideal properties of a bearing metal are:

1. Ability to stand high compression load without cracking or squeezing out.
2. Small dimensional change under excessive load and at high temperatures.
3. Low coefficient of friction.
4. Ability to run dry without melting the bearing or scoring the shaft.

The extremely hard and tough bronzes satisfactorily met the first two requirements, passed the third as long as lubrication was ample, but appeared to fail upon the fourth.

The foregoing conditions are met by the high lead bronzes which have come into such general use during the last few years. Bronzes containing a high percentage of lead have been known and used for a great many years, but their high cost of manufacture has prevented their adoption for general bearing purposes. This was due to the difficulty in producing a bronze having a high lead content which did not result in segregation of the lead, as a result of which the metal was not uniform, was very difficult to machine and generally unsatisfactory for any purpose whatsoever. The existing processes for producing a high lead bronze which was homogeneous were so difficult and expensive that the cost was prohibitive, although it had always been recognized that such a material would be ideal for bearing purposes. Recent developments have made the high lead bronzes available at prices that compare favorably with the phosphor bronzes and the other high-grade bearing metals, and as a result they are now being widely used in machinery and equipment of all kinds. These bronzes have a coefficient of friction that approximates the babbitt group, and although it is not recommended that any bearing should be run without lubrication, their high lead content provides a self-contained lubricant in sufficient quantity to prevent cutting or damage to a steel shaft even though the bearing be run dry under a load.

The only question as to the desirability of the high lead bronzes for bearing purposes lies in their lower tensile strength and hardness which, in some cases, is such that under excessive loads or pounding, they will deform or squeeze out. This is prevented by including in the composition of the bronze, sufficient tin or other metals to raise the tensile strength and hardness to the required point and yet not affect the self-lubricating and non-cutting qualities of the metal. Such metal is being satisfactorily used in rolling-mill machinery where the bearing pressures are enormous and where the high temperature makes satisfactory lubrication difficult. They are also successfully used in high-speed electric-motor and turbine bearings as the other extreme, and throughout the entire range of machinery and equipment between the two, are giving satisfaction.

The remarkable performance records of these metals make them of especial interest in connection with textile and printing machinery where an absolute minimum of lubricant must be used through danger of damage to the product; in baking, dairy and creamery machinery where the use of lubricant in any quantity contaminates and spoils the product; and for all other conditions where lubrication is difficult or inaccessible, or where difficulty is being experienced with the harder and tougher bearing bronzes.

Speed Adjustment of Direct-Current Motors Field or Armature Control

Adjustable and Varying Speed—Speed Control of Shunt and Series Motors With Field Resistance—Speed Control with Armature Resistance—Application Best Suited to Each Method of Speed Control

By GORDON FOX

Electrical Engineer, Freyn Brassert & Company, Chicago, Ill.

THE ordinary shunt motor is primarily a constant-speed machine, whereas the speed of the series motor varies over a wide range, depending on the load and the compound-wound motor has a speed characteristic between the shunt and series. Automatic variation in the rate of rotation with change of load is termed speed regulation, and motors whose speeds

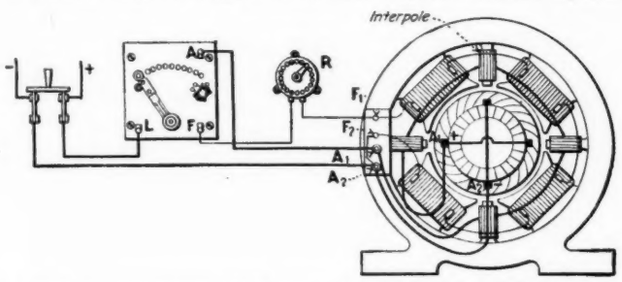


FIG. 1—CONNECTIONS FOR AN ADJUSTABLE-SPEED INTERPOLE SHUNT MOTOR

fluctuate widely in this manner are called varying-speed motors. It is possible to control the speed of a direct current motor by external means. Change of rotation rate by modification of operating conditions is termed speed control. The speed of some direct-current motors can be varied gradually over a considerable range, remaining, for each setting, practically unaffected by the load. Such motors are called adjustable-speed motors. The difference between varying speed and adjustable speed should be clearly understood. The terms are often confused by those who do not comprehend their exact meanings. Likewise, the distinction between speed regulation and speed control should be noted.

Adjustable-Speed Motor Performance

The adjustable-speed direct-current motor is dependent for its performance upon the fact that the counter-voltage in the armature is proportional to speed and field flux. If the field current be changed, the field magnetism is affected. This, in turn, requires a change in speed in order that the proper counter-voltage be maintained. If an adjustable resistance be connected in series with the shunt field of a shunt motor or a compound-wound motor having a small degree of compounding, the speed may be adjusted to any desired point within limits and will remain approximately constant at that point regardless of load changes.

Fig. 1 shows the connections for an adjustable-speed interpole shunt motor. The machine is designed to operate at the lowest speed in its range as a simple shunt motor. As resistance is introduced into the shunt-field circuit by rheostat *R*, the speed increases to a value corresponding to the setting of the rheostat and the motor will then operate at practically constant speed irrespective of the load as long as the field rheostat is unchanged and the line volts is constant.

Motors are built commercially with speed ratios of two to one, three to one or four to one, and they have been built for ratios as high as six to one, with field control. In other words, the maximum speed may be two, three or four times the minimum speed, the number of increments of speed depending upon the number of divisions of resistance in the control rheostat. The wider speed ranges are confined to the small motors. Large motors are more limited as to the feasible speed range by field control. The maximum speed is limited by mechanical considerations. It is also more difficult with the greater number of poles used on the larger machines to secure winding combinations that will give the desired minimum speed with sufficient commutator bars to restrict properly the maximum voltage between bars.

Horsepower Depends on Torque and Speed

The horsepower output of a motor depends on two elements, torque and speed. Torque is proportional to field flux and armature current. As an adjustable-speed motor increases its rotation, it requires less torque to develop a given horsepower output. Since the increase in rotation is gained by weakening the field, it is evident that the available torque per ampere armature current falls off to a like degree. A motor of this type is thus inherently adapted to developing the same horsepower at all speeds in its range. At high speeds the field current is low and the armature current required to develop the torque corresponding to rated horsepower output is normal. The windings are thus worked

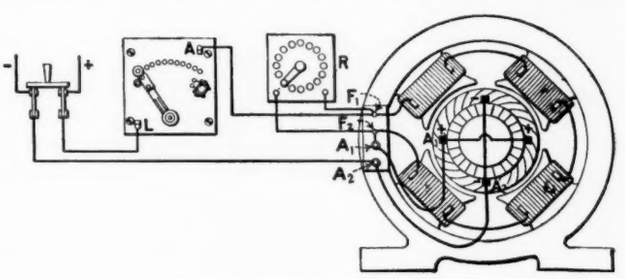


FIG. 2—CONNECTIONS FOR ADJUSTING THE FIELD OF A SERIES MOTOR WITH A PARALLEL RESISTANCE

at or below normal, the ventilation is good and there is a lesser tendency for the machine to heat under high-speed operation.

At the lowest speed maximum field current flows and the iron is saturated. A higher torque is required to develop rated horsepower at the lower speed and approximately the same armature current is taken as at high speed. Since the windings are worked harder and the ventilation is poorer, the heating tendency is more pronounced. Temperature rise and torque limit the

horsepower rating at low speed. Consequently, the frame size is determined by the low-speed rating and must correspond to that of a constant-speed motor rated at the rotation corresponding to the minimum speed of the adjustable-speed motor.

A 5-hp. 400- to 1,600-r.p.m. adjustable-speed motor for continuous service and a 5-hp. 400-r.p.m. constant-speed motor are approximately the same size. Motors designed for low speeds are larger and more costly than those delivering the same horsepower at higher speeds, owing to the greater torque required per horsepower output. This being the case, a drive using an

FIG. 3—CONNECTIONS FOR VARYING THE SPEED ON SHUNT MOTOR WITH RESISTANCE IN ARMATURE CIRCUIT

adjustable-speed motor may be more costly than one using a constant high-speed motor with mechanical speed-changing devices.

Since the field current of a shunt motor does not exceed 2 per cent of the total load current the loss incident to insertion of resistance in this circuit is small, and this is a highly efficient method of speed control. As a rule the efficiency at low speed is slightly higher than at high speed. The iron loss and field copper losses are greater at low speeds, but the losses due to windage and brush and bearing friction at high speeds usually more than offset the gain.

Adjustable-speed shunt-wound motors are extensively used for individual drives where a selective range of speeds is desired together with good regulation at any point. High efficiency, easy and exact manipulation and steady running render the system generally the most satisfactory adjustable-speed drive available. Motors of this type are used extensively for machine-tool work where their characteristics fit the requirements to a nicety.

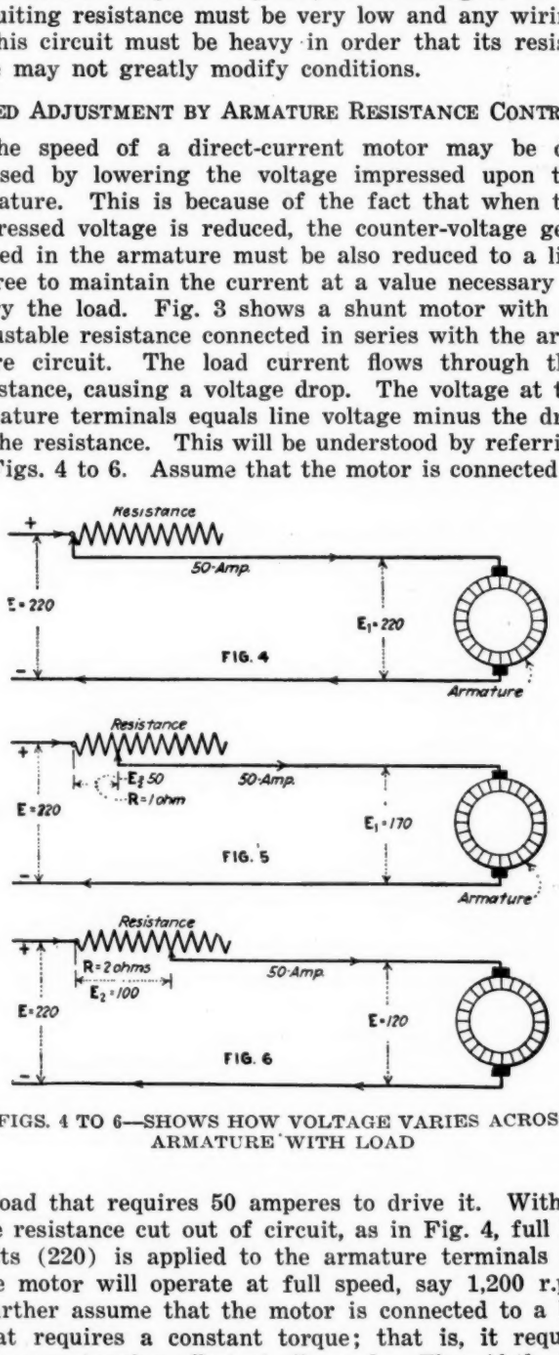
Motors for Adjustable-Speed Service

Adjustable-speed motors are designed especially for their service. Because of the fact that satisfactory commutation cannot be secured upon an ordinary shunt motor running with greatly weakened field, it is necessary to provide interpoles to aid the commutation. Practically all field-controlled adjustable-speed motors are now of the interpole type. It is possible and feasible to secure a small range of speed adjustment upon almost any shunt or compound direct-current motor by the insertion of a field rheostat. The permissible increase is limited to about 25 per cent in most cases, as commutation will be poor at higher speeds. Not infrequently, a slight speed increase in a machine driven by a constant-speed motor will result in increased production. In such cases the possibilities of field control are not always fully appreciated.

The use of a rheostat in series with the field circuit is applicable only to the shunt field of a shunt- or compound-wound motor. In a series motor the field strength cannot be regulated by connecting the series resistance in the field circuit, since both field and armature are in series. Speed adjustment by field control is not common practice with series motors. It does find a few applications, however. The field may be adjusted either by connecting a resistance in parallel with the field winding, as in Fig. 2, and shunting a part of the load current around the field winding, or by short-circuiting a part of the field turns. Either arrangement serves to weaken the field and thus increase the speed. Inasmuch as the resistance of a series field is comparatively low, the shunting or short-circuiting resistance must be very low and any wiring in this circuit must be heavy in order that its resistance may not greatly modify conditions.

Speed Adjustment by Armature Resistance Control

The speed of a direct-current motor may be decreased by lowering the voltage impressed upon the armature. This is because of the fact that when the impressed voltage is reduced, the counter-voltage generated in the armature must be also reduced to a like degree to maintain the current at a value necessary to carry the load. Fig. 3 shows a shunt motor with an adjustable resistance connected in series with the armature circuit. The load current flows through this resistance, causing a voltage drop. The voltage at the armature terminals equals line voltage minus the drop in the resistance. This will be understood by referring to Figs. 4 to 6. Assume that the motor is connected to



FIGS. 4 TO 6—SHOWS HOW VOLTAGE VARIES ACROSS ARMATURE WITH LOAD

a load that requires 50 amperes to drive it. With all the resistance cut out of circuit, as in Fig. 4, full line volts (220) is applied to the armature terminals and the motor will operate at full speed, say 1,200 r.p.m. Further assume that the motor is connected to a load that requires a constant torque; that is, it requires the same turning effort at all speeds. Then if the load requires 50 amperes in the motor to drive it at full speed, it will require 50 amperes at all speeds, therefore the current will remain constant.

If the controller is adjusted so that 1 ohm resistance is in series with the armature, as in Fig. 5, the volts

across the motor terminals will be reduced and the motor will slow down. The volts drop across the resistance is equal to the resistance in ohms (1) times the current in amperes (50) or $1 \times 50 = 50$ volts. If 50 volts is required to cause the current to flow through the resistance, only $220 - 50 = 170$ volts is available at the armature terminals and the speed will decrease to correspond to this voltage. Where the torque is constant, the speed decrease is in direct proportion to the voltage, or $220 : 170 :: 1{,}200 : X$, from which the new speed $X = \frac{170 \times 1{,}200}{220} = 927$ r.p.m.

If the resistance in series with the armature is increased to 2 ohms, then the volts drop through it will be 2×50 or 100 volts. This leaves $220 - 100$ or 120 volts at the armature terminals, as in Fig. 6, and the corresponding speed will be $X = \frac{120 \times 1{,}200}{220} = 654.5$ r.p.m. In the first case the speed decreased from 1,200 to 927, or a reduction of 273 r.p.m., and in the latter from 1,200 to 654.5, a reduction of 546.5 r.p.m., or twice that in the first case. From this it is seen that where the torque remains constant, the speed decreases in proportion to the resistance in series with the armature.

Inasmuch as the armature current at light loads is small, there is little drop, even with comparatively high resistance. Consequently, the speed at light loads is nearly the same as if there were no resistance in the circuit. For example, consider, in Fig. 6, that the load is decreased to where only 10 amperes is required to drive the motor. Then the drop through the resistance is $2 \times 10 = 20$ volts, which leaves $220 - 20 = 200$ volts at the armature terminals. This will cause the speed to increase to $X = \frac{200 \times 1{,}200}{220} = 1{,}091$ r.p.m. From this it can be seen that this method affords little speed adjustment for light load conditions. The heavier the load the greater the speed range available.

Speed Range by Armature Control

It should be noted that the speed range obtained by armature resistance control lies entirely below the normal rated speed of the motor, whereas, with field control the speed range lies above this point. Sometimes the two methods are employed to obtain a range greater than that afforded by either method singly. This is particularly feasible if the load at reduced speed is relatively light or if slow-speed operation is only occasional or intermittent.

Since the degree of speed variation secured by the armature resistance depends upon the load, it is necessary that exact working conditions be known if correct speed values are to be obtained. Consider, as an example, where the speed of a 10-hp. 1,200-r.p.m. motor is intended to be reduced to 600 r.p.m. under full load. A controller is supplied such that, with all resistance cut in, the speed will be 600 r.p.m. under a 10-hp. load. After installation it is found that the load requires but 8 hp. The current corresponding to 8-hp. load will be sufficient to bring the speed down to only about 710 r.p.m., therefore the desired minimum speed, 600 r.p.m., cannot be attained without connecting in additional resistance.

The manner in which the resistance should be subdivided depends upon the driven machine. In the case of a job printing press the load is largely frictional and the horsepower increases with the speed. In some drives the heavier work is done at the slower speed so that approximately constant horsepower is required. When driving fans, the load decreases approximately as the square of the speed and at low rates the work is light. It should be evident that, if uniform graduations of speed for each controller step are to be secured with these different types of load, the resistance must be proportioned accordingly.

A successful armature control application requires a definite preliminary knowledge of the exact load and its behavior with respect to the speed. These data must be furnished the controller manufacturer to enable him to fit requirements rightly. Insufficient and inexact data are a frequent cause of unsatisfactory performance of armature-control installations.

Since the entire load current of the motor passes through the resistance of an armature-control speed regulator, the loss therein may be considerable. Since the field strength remains constant, the armature current at any speed depends on the torque demanded at that speed. With a constant-torque load the armature current is the same for all speeds, therefore the resistance loss increases directly as the speed is reduced.

Losses Increase as the Resistance In Series With the Armature

A further consideration of Figs. 4 to 6 will show how the losses increase as the resistance is increased in series with the armature. In Fig. 4 the armature is connected directly to the line and the total watts, volts times amperes $= 220 \times 50 = 11{,}000$, is supplied to the motor. With 1 ohm resistance connected in series in the armature circuit, Fig. 5, there is a drop of 50 volts. The watts loss in the resistance equals volts drop times current, or $50 \times 50 = 2{,}500$, which leaves $170 \times 50 = 8{,}500$ watts supplied to the armature. In Fig. 6 the loss in the resistance is $100 \times 50 = 5{,}000$ watts, therefore the power supplied to the armature is $120 \times 50 = 6{,}000$ watts. The power expended in the resistance is a loss since it does no useful work.

If the torque demand decreases with reduction in speed, both the output and the input are correspondingly reduced and the efficiency is still approximately proportionate to the speed. In such a case, however, the actual losses do not increase in proportion to the speed reduction, owing to the decreased torque and consequently decreased current. In any case the losses are less serious as full rated speed is approached. The allowable speed reduction is limited both by poor speed regulation and by resistance losses. About 25 per cent speed reduction is quite satisfactory for continuous-running drives, 50 to 90 per cent being used for intermittent driving with frequent adjustment by an operator.

Armature control is suited for highly intermittent duty, for manual regulation and for continuous drives requiring constant torque or decreased torque at decreased speeds. Because of poor-efficiency and fluctuating-speed tendencies the applications are limited. It is not at all suited for machine-tool drives where changing loads and exact, constant speeds are desired. It is used extensively for traction service, cranes and hoists, operations where the speed is continually under manual control. It is used for printing presses and elsewhere for slow-speed "setting up" work, where the motor normally operates at higher speeds. It is applied to a considerable extent for blowers and fans where the load is steady and the maximum motor capacity is required at high speed, but where, at low speeds, the losses are greatly reduced because of the lesser loads.

Carbon Dioxide Versus Ammonia as a Refrigerant

By H. J. MACINTIRE
Associate Professor of Refrigeration, University of Illinois

WHILE carbon dioxide is a cool condensing-water refrigerant, requiring more power and more cooling water per ton and higher operating pressure than ammonia, it is the best "safety" refrigerant known, and for this and other reasons its use is on the increase. The accompanying charts show in condensed form the operating requirements of the two refrigerating mediums.

THE refrigerating machine using carbon dioxide came into use about forty years ago (in 1882) and therefore only about six years after the first successful ammonia compression machine was devised by Carl Linde. Yet since then the ammonia machine in this country has become strongly established, whereas carbon dioxide as a refrigerating medium has had a hard fight and a successful one only in certain classes of work. There must be a particular reason for this partiality which is worth while going into in detail.

It is frequently said that the pressure range encountered in the use of carbon dioxide is the reason for the preference of ammonia, but this is not conclusive. The fact that pressures of 800 to 1,000 lb. per sq.in. or over are met with is not insurmountable. At the present time steam pressures of 350 lb. are common and 500 to 600 lb. are beginning to be used. The existence of a gas pressure is not serious in these days when good quality steel and wrought-iron pipe is available and the flanged joint can be cheaply produced and made tight. Also the use of welded pipe is doing away with all except a few of the flanged joints.

With regard to the action of carbon dioxide in the compressor, except for the fact that heavy unit pressures

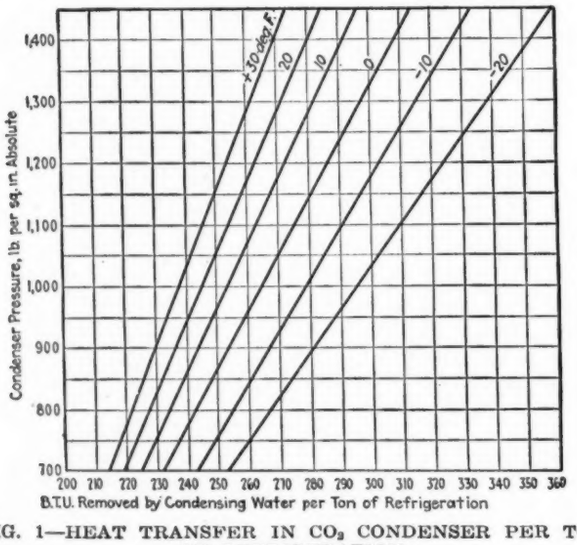


FIG. 1—HEAT TRANSFER IN CO_2 CONDENSER PER TON OF REFRIGERATION

are carried and therefore that the cylinder has to be constructed satisfactorily for this purpose, the machine has a simpler problem than many ammonia compressors in daily use. In gas compression there is interest primarily in the ratio of the suction and the discharge pressures, or $P_2 \div P_1$. The temperature of the discharged gas as well as the work done on the gas is in proportion to some function of this ratio of pressures. As a matter of fact the dry-vacuum air pump for steam-turbine use, which discharges into the atmosphere, has a much more severe duty, as has also the air compressor discharging compressed air at 100 lb. gage, than has the carbon-dioxide compressor operating at 0 deg. F. (303 lb. abs.) and with a condenser pressure of 1,000 lb. In the first

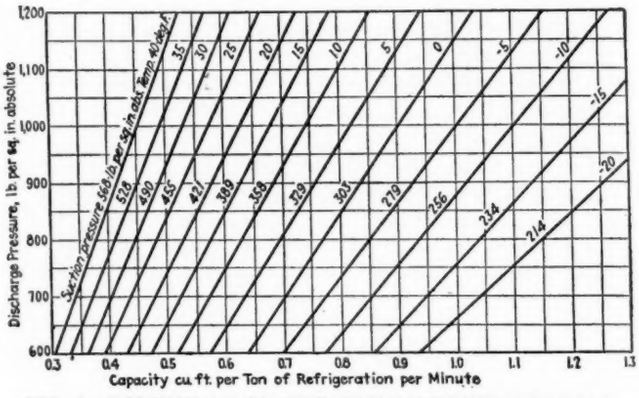


FIG. 2—VOLUME OF CO_2 PER TON OF REFRIGERATION
No liquid cooling; dry compression; allowance made for real volumetric efficiency.

case the ratio of the discharge pressure to the suction pressure is approximately $15 \div 0.5 = 30$; in the second the ratio is $115 \div 15 = 7\frac{2}{3}$, and in the third case the ratio is $1{,}000 \div 303 = 3.3$.

Size of Compressor

From the foregoing it is questionable whether the pressures alone existing in the refrigerating cycle exert a deciding influence on the selection of any refrigerant except in particular cases. There must be some other reason for a preference. This may be as regards the size of the compressor per ton of refrigeration. The carbon-dioxide compressor has the advantage, however, in this case even with warm condensing water. At 0-deg. F. boiling temperature of the refrigerant and with 70-deg. F. condensing water the carbon-dioxide compressor requires about 1,500 cu.in. piston displacement per ton of refrigeration per minute and the ammonia compressor for the same conditions requires about 8,000 cu.in. The carbon-dioxide compressor, therefore, has a decided advantage as far as the piston displacement is concerned for nominal temperatures of cooling water and boiling temperatures of the refrigerant. But this advantage is not uniform.

It is well known that carbon dioxide has a low critical temperature. At and above 88.4 deg. F. the carbon-dioxide vapor cannot be condensed no matter what the pressure on the vapor may be. Should the high-temperature condenser water only be at hand—as, for example, cooling-tower or spray-nozzle water at 90

deg. F.—then the pressure in an ammonia plant would be about 200 lb. gage and in the carbon-dioxide plant about 1,400 lb. The carbon dioxide would not condense in the condenser as we understand it, for it will not condense at 88.4 deg. or at any point above the critical temperature. The mistake must not be made that it ceases to act as a volatile liquid, however. Some engineers believe that carbon dioxide can give no refrigeration at all with condenser temperatures above 88.4 deg. F., and others claim that the refrigeration is slight and comparable with what would be possible with a "dense gas," as air for example. Neither of these ideas is correct. The so-called critical temperature is where the "latent heat" of liquefaction is zero, but the vapor above this temperature is dense and behaves much like a liquid. On passage through the expansion valve, the uncondensed gas becomes part liquid and this liquid is the means for the useful refrigeration obtainable.

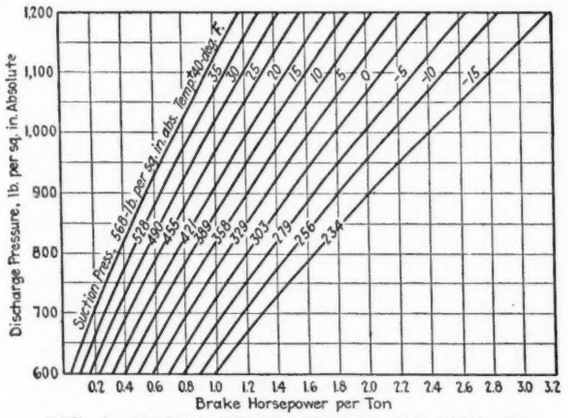

Discharge Pressure, lb. per sq. in. Absolute
Brake Horsepower per Ton
Suction Press., 568-lb. per sq. in. abs. Temp. 40 deg. F.
1,200
1,100
1,000
900
800
700
600
0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2

FIG. 3—BRAKE HORSEPOWER PER TON OF REFRIGERATION FOR CO_2

Dry compression; no clearance; b.hp. = i.hp. + 10 per cent.

There is this disadvantage, however: The latent heat for carbon dioxide is much smaller than that for ammonia, being from 130 to 115 B.t.u. per lb. for ordinary boiling temperatures, whereas ammonia is from 597 to 569 B.t.u. In spite of the fact that the specific heat of ammonia is greater than unity and that for carbon dioxide it is about 0.33, the proportion of useful refrigeration is less at usual refrigerating conditions than for ammonia. For example, the ratio of possible refrigeration at 50 deg. F. and at 80 deg. F. condensing temperature in each case, with 0 deg. F. boiling temperature, is for ammonia 0.934 and for carbon dioxide, 0.795. This loss for carbon dioxide becomes even greater with cooling water of higher temperature in the condenser, but it may be said that the usual loss of capacity is that shown with an 80-deg. condenser condensate, representing a fairly liberal amount of 70-deg. F. cooling water. However, this does not show the whole story, as will now be explained.

In the table the boiling temperature in the evaporating coils is taken as 0 deg. F.

AMMONIA VERSUS CARBON DIOXIDE

	Net Refrigeration per Lb., B.t.u.				Ratio of Capacity With 80 Deg. Liquefaction To That at 50 Deg.
Liquefaction temperature....	50	60	70	80	.....
Ammonia.....	13.7	502.4	491.1	479.6	0.934
Carbon dioxide.....	89.2	83.1	77.0	70.9	0.795

Using 70-deg. F. cooling water and the resulting 80-deg. condensate with 0-deg. boiling temperature of the refrigerant, the net theoretical refrigerating effect of the two refrigerants are:

611.6 — 132.0 = 479.6 *B.t.u. per lb. for ammonia.*

99.8 — 28.9 = 70.9 *B.t.u. per lb. for carbon dioxide.*

If the liquid refrigerant could go to the expansion valve at 0 deg. F., the temperature at which refrigeration in this assumed case takes place, then there would be 568.7 B.t.u. per lb. for ammonia and 117.5 B.t.u. per lb. for carbon dioxide. The ratio of useful refrigeration for ammonia would be 479.6 ÷ 568.7 = 0.844, and for carbon dioxide, 70.9 ÷ 117.5 = 0.604. In other words, because of the fact that the condenser usually cools the condensate to a temperature some 5 to 10 deg. or more above the initial temperature of the cooling water, the refrigerant has to cool itself at the expansion valve to the evaporating temperature before useful refrigeration can be performed. The 80-deg. liquid, then, has to be reduced to 0 deg. F., and in the performance of this duty some liquid is evaporated and this becomes useless for further refrigeration. This loss is, for the case stated, about 15 per cent. for ammonia and 40 per cent. for carbon dioxide.

Condenser Temperatures

The crux of the whole matter is that carbon dioxide is a cool condensing-water refrigerant not to be preferred for use in the case of hot sea water, tropical surface water or for the usual cooling-tower installations where the water available for the condenser rises in temperature in the condenser to a point near or above the critical temperature for carbon dioxide of 88.4 deg. F. Carbon dioxide suffers also with a wide range in the operating conditions as in the case of the 0-deg. boiling temperature and the 80-deg. condensate example given previously. This is because the latent heat of vaporization of carbon dioxide is small as compared with ammonia and because a relatively larger amount of possible refrigeration is consumed in cooling the liquid. This amount of liquid boiled in cooling the liquid from the

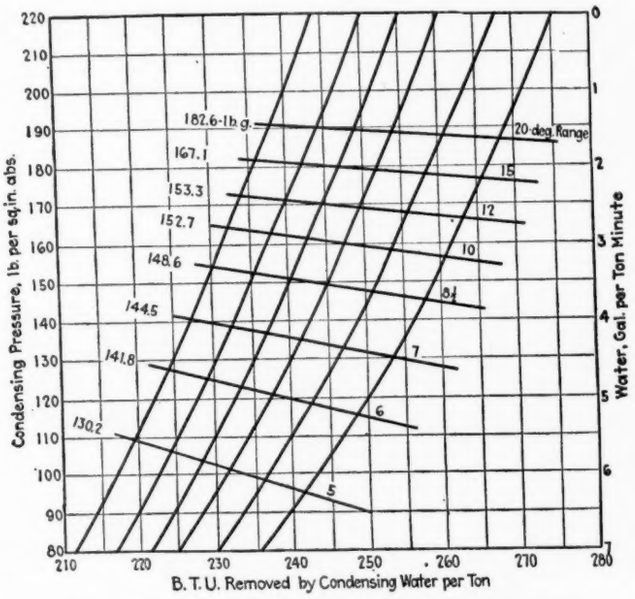


FIG. 4—B.T.U. REMOVED PER TON IN AMMONIA CONDENSER

No liquid cooling; 70-deg. F. initial temperature cooling water.

condenser is returned to the compressor and has to be compressed with the vapor which has performed useful refrigeration. The horsepower per ton of refrigeration and the water used in the condenser are influenced directly by these losses, and it should be expected that both the horsepower per ton and the amount of water used for any particular set of conditions would be greater than would be required for ammonia.

Advantages of Ammonia

Figs. 1 to 6 inclusive show better than has ever been presented before, the relative advantages of ammonia. The brake-horsepower per ton for similar operating conditions is about 10 to 25 per cent greater for carbon dioxide than for ammonia. In each case the mechanical efficiency is assumed to be 90 per cent. and allowance is made for the volumetric efficiency of the compressor. The piston displacement per ton per minute is, however, much smaller for carbon dioxide than for any other refrigerant, although, because of the heavy unit compressor pressures and the resulting desire to decrease the cylinder bore, but to compensate for the same by a long stroke as compared with the bore, the compressor stroke and therefore the frame, the flywheel and the condenser are of the same proportions or larger than for ammonia.

These are the reasons why carbon-dioxide compressors are not adaptable in the United States for ice making

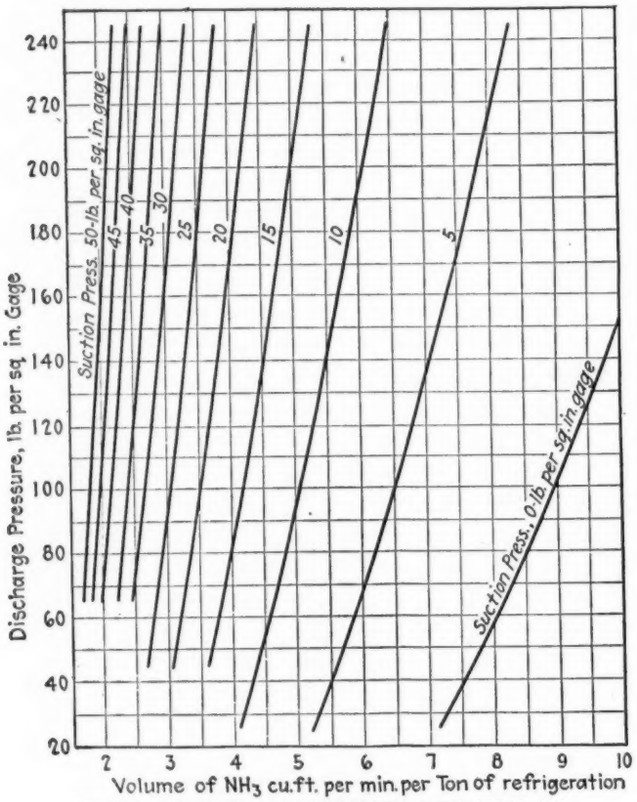


FIG. 5—VOLUME OF AMMONIA PER TON OF REFRIGERATION

No liquid cooling; volumetric efficiency considered.

except as part of a hotel or hospital plant, or for cold-storage work or in the packing-house and chemical industries, where the cost of a ton of refrigeration per hour or per 24 hours is of sufficient importance to be considered above other factors. In ice making the primary consideration where competition is at all keen is whether 40, 50 or 60 kw.-hr. are required per ton of ice. If carbon dioxide is used as a refrigerant, then, it must be for reasons more pressing than those already outlined, and the advantages of carbon dioxide are to be found at times in the safety element, both as to the explosion possibilities and as to its effect on people should the refrigerant escape into the atmosphere of the building.

Carbon dioxide is innocuous even in large proportions in the air. It is non-inflammable and cannot explode. In fact, it will put out rather than start fires, whereas

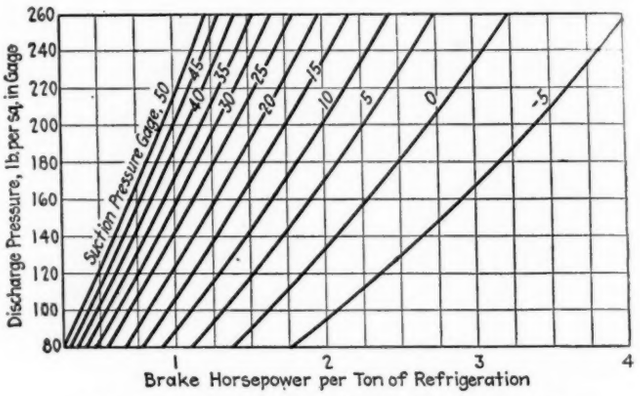


FIG. 6—BRAKE HORSEPOWER PER TON OF REFRIGERATION

No liquid cooling; volumetric efficiency considered; based on horizontal double-acting ammonia compressor; b.hp.=i.hp.+10 per cent.

ammonia will explode in certain restricted proportions, and propane, the new refrigerant obtained from casing-head gas and one of the many compounds found in gasoline, is highly combustible and an explosive. It is claimed to be harmless to humans in small proportions in the air, but it appears that carbon dioxide is the real safety refrigerant in every sense of the word and as such will be used extensively for marine work, in hospitals, hotels, theaters and other constricted places, or where the public safety demands a safety refrigerant.

It is also probable that carbon dioxide will find a use in smaller installations where the cooling water is 70 deg. F. or lower and where the actual power consumed is not an important factor. There are persons in terror of ammonia, and commodities that are injured by its fumes. The small market man, florist, confectioner, fruit and vegetable dealer, etc., might readily prefer a refrigerant that will not make its presence known by leaks or by rupture and will not therefore cause panics or unwelcome publicity. The carbon-dioxide compressor, in the opinion of the author, deserves greater popularity for the restricted uses mentioned. It is certain to be more extensively used, and engineers should study its cycle and become generally familiar with the construction and the limitations.

One of the interesting subjects discussed at the recent meeting of the American Society of Heating and Ventilating Engineers was the effect of temperature and humidity on the comfort and efficiency of human beings, and a chart that has been prepared showed that while a temperature as high as 70 deg. may be necessary to comfort under dry conditions, such as usually obtained in rooms during the winter, the addition of moisture to the air will make a lower temperature, say 60 deg., equally comfortable. This opens up possibilities for large savings of coal and is of considerable importance

Boiler Inspecting—II

By James F. Hobart

THIS article, the second of a series, describes the proper method of cooling down, and blowing of the boiler, also the cleaning necessary prior to inspection.

THE boiler should be prepared for inspection as will be described in the following paragraphs. All too often nothing is done to get the shell ready and the inspector must waste his time doing work that should be done by unskilled labor; that is, cleaning in, under and around the boiler.

To begin with, the boiler should be emptied, washed cleaned of all dirt inside, and the outside of the shell scraped clean of all ashes. When emptying a boiler, do not blow off all the water while it is under pressure. It is well enough to blow down a few gages while steam is at full pressure and the fire at the greatest heat. At such times, the loose dirt in the boiler will be in circulation with the water and a considerable quantity of it will be thus removed from the boiler.

The "blowing down" should be done while the boiler is active, not after the engine has been shut down. The proper way to close down a boiler for inspection is to let the fire go out or to draw the fire if there is little time available. Do not blow off the boiler while it is under pressure. Let it stand until cool, then let the water run out through the blowoff, and be sure to vent the boiler by opening it above the water line, either by a gage cock, by disconnecting the steam gage, or in some other convenient manner.

Cooling a Hot Boiler

To cool a hot boiler, do not make the mistake of opening the "smoke-front" doors, thus letting cold air directly upon the hot tube ends. After the fire has been drawn, open the stack damper wide, then open the ashpit doors and leave the furnace doors closed. This will allow cold air to pass under and through the boiler in the usual manner, becoming somewhat heated by radiation from the walls and consequently doing no damage to the boiler seams and tube ends. When cold air is allowed to flow directly upon these surfaces while they are hot, leakage is likely to be developed if nothing more serious occurs, and cracks and broken rivets are not beyond the possibilities.

As soon as the boiler has cooled down and the pressure has dropped to zero, open the blowoff valves. Then break in the manhole, remove the cover and take it out of the boiler as soon as the hot vapor, which escapes as soon as the gasket is broken, will allow. Then, as soon as possible, remove the handhold plates and let air circulate through the boiler.

The furnace lining will have cooled a good deal by this time and the firedoors may be opened, the clean-out door to the back combustion chamber also opened, but the "smoke front" doors should as yet remain closed, except for the time necessary to remove the front manhole and hand-hole plates.

Washing Out

When a boiler is opened as described in the foregoing, considerable dirt will remain inside, and as soon as the boiler shell is cooled to the degree that cold water will not harm it, a hose should be introduced with as powerful a stream of water as possible, and the tubes and shell washed free of all sediment. Do not wash out a boiler with cold water when the sheets are hot, for so doing will cause strains in the metal. In cases where boilers must be washed out without taking the time necessary to cool them off as already described, hot water should be used for the washing. If the boiler is one of a battery, simply attach a hose below the water line of the other boiler to the blowoff if regulations allow no other opening below the water line. Fill the live boiler pretty full of water and use it to wash the boiler to be inspected. In some instances a boiler washer may be used for heating the wash water, as is frequently done with locomotive boilers for washing out while the boiler is hot.

Wash from above, through the manhole, also from the front end of the boiler through the hand-hole, and if necessary use a stream of water through the rear hand-hole to break up the pile of mud frequently found near the back end of the boiler. In some localities it is well to save a portion of the sediment removed from the boiler and show it to the regular inspector in order that he may take such action as he may find necessary in the recommendation of feed-water purifiers, mechanical or chemical, or a more frequent cleaning out of the boiler.

Cleaning the Shell

As soon as the fire has been removed from the grate, the cooling of the shell may be hastened by removing the dust and ashes from the back combustion chamber. Have this chamber cleaned out thoroughly and the walls swept clean. Also, have the back end of the boiler well cleaned of all dust and dirt, well swept with a stiff brush or a sawed-off broom.

As the boiler cools so that the firedoors can be left open, repeat the brushing and cleaning, this time in the combustion chambers. Sweep the shell as far up on each side as the setting will permit. Clean off the bridge wall and take all the dirt and ashes therefrom, and from the surface of the boiler back of the combustion chamber.

As soon as the boiler and its setting have cooled sufficiently to permit the opening of the smoke-front doors, scrape the tubes clean. Do not "blow out" the tubes with steam from another boiler, for that action wets and gums the cold tubes, covering the ends with a mixture of water and dirt. Clean out the front end, scrape the smokeboxes, clean and brush all the dirt off the front end of the boiler. In short, clean the boiler well before inspection is attempted, thus saving time and patience and permitting the engineer to devote all his energy to determine the actual condition of the boiler and the safe working pressure it should be allowed to carry.

Dirty Boilers Rated Low

When a regular boiler inspector meets with a dirty boiler, he is likely to play safe by rating the safe working pressure considerably lower than the boiler is really fit to carry. The engineer, while inspecting some boiler, may be forced to do this in order to protect himself against conditions that might be present but so obscured by dirt that he cannot detect them. Thus, it surely pays to have a boiler nicely cleaned before inspection is attempted.

After opening and cleaning the boiler there is still a lot of work to be done—if not previously accomplished—before the engineer may don his suit and with hammer and candle crawl into the shell. Before beginning to inspect, the history and data of the boiler should

be looked up and its measurement carefully looked over.

When an insurance inspector is sent to make a regular internal inspection, he first obtains the data sheet of the boiler and looks it over carefully. Then he obtains from the insurance files the records of previous inspections and makes himself familiar with the condition of the boiler at the time the last inspection was made; and with whatever recommendations were made, and of new things observed in connection with the boiler.

Thus, in case of a regularly inspected boiler the inspector knows where to look for weak points if any and is also aware of any peculiarities the boiler may possess. But when a new boiler or an old one not previously inspected must have attention, then the engineer must first obtain all the data concerning the material and workmanship of the boiler in question. Unless such data be obtained, the true condition of the boiler cannot be as closely determined.

Make a Data Sheet

So important is the matter of obtaining complete data of any boiler to be inspected for safety, that the boiler insurance companies provide elaborate and comprehensive sheets, one of which must be carefully filled out with the data of each boiler which is to be inspected and insured. Many times, the data of a boiler is known by and may be obtained from its manufacturer; in which case, the engineer will be spared the labor of making all measurements relating to thickness of sheets, rivets, spacing, bracing, etc. When an engineer or any other person inspects a boiler for the purpose of determining its condition and the safe working pressure it may be allowed to carry, he must have certain facts and if he cannot obtain them ready for use beforehand, then he must work out the figures from the boiler by making actual measurements. In that case, certain things may have to be assumed, such as tensile strength of shell plates, etc., in which case he must protect himself by giving the minimum strength of steel plates.

To be sure, it is not possible to obtain from an old boiler the tensile strength of the sheets. That can be determined only by an actual test made in a testing machine. But where full data are required, the engineer must assume a plate strength which he proceeds to do and always makes his assumption low even if it cuts down the working pressure more than the computation based on the actual strength of the material if known would do.

Condemning a Boiler

A regular boiler inspector never condemns a boiler. When you make an inspection, Mr. Engineer, bear in mind that you are seeking to obtain data from which may be calculated the bursting and the safe working pressure of that particular boiler. The latter figure is all that you are after. Find the condition of a boiler, then, as accurately as possible, fix the safe working pressure thereof and you never need trouble about condemnation proceedings.

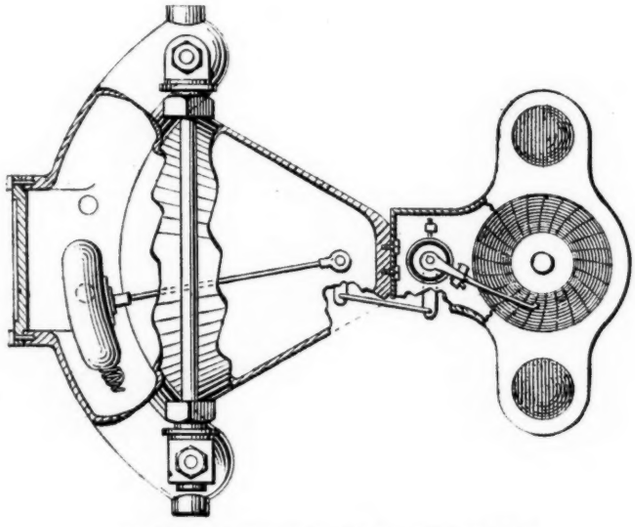
If you find that the boiler has deteriorated, simply cut down the safe working pressure, and then the owner of the boiler will do his own condemning—or have the repairs or renewals made which are necessary to maintain the original safe working pressure.

A loss of strength by one part reduces the working strength of the entire boiler, hence watch closely, and let nothing go past not looked at and take nothing for granted. Be sure that you know the condition of each and every part of the boiler which you examine and be sure to examine them all.

Gives Continuous Record of Water Level

In boiler operation safety demands intimate and continuous knowledge of the water level, and from the viewpoint of economy it is important that the water level be maintained as nearly constant as possible. In this connection the combination of safeguards incorporated in the new water-level recorder developed by W. C. Hackman, 305 Metropolitan Building, Milwaukee, Wis., should prove of interest.

In addition to the usual water-column connections, with an illuminated gage glass visible from any angle, the device contains a bell and light system to warn of high and low water, and a feature new in power-plant practice, that of employing a gage to give a continuous record of the water level. A 24-hour chart shows the water level during operation and banking hours, indicates when the boiler is cut in and out, and makes evident the periods of blowdown both of boiler and water column.



HACKMAN WATER-LEVEL RECORDER

This chart serves as an excellent guide to the fireman and also as a check on his services. Knowing that his actions are recorded, he will be prompted to maintain the water level uniform and to blow down the water column, gage glass and boiler at the specified intervals. From the opposite viewpoint, the water tender will welcome the record, as it gives concrete evidence of the care and attention he gives his boilers. The signals are for emergencies only, such as negligence, incapacitation of a fireman, or foaming, which affects the recorder just as does low water.

Reference to the figure will show the arrangement of the recorder. In a water column of the shape indicated, an oblong float is attached to a lever which actuates a shaft passing out through a stuffing box to operate the recorder pen and make the electric contacts for the signal system. The float, traveling on an arc, rises and falls with the water level and its movement is transmitted to the recorder pen.

Getting an Engine Into Service After a Breakdown

By M. S. Howard

Carelessness is the cause of much expense and of many shutdowns in power plants. The most unfortunate thing about this is that it reacts upon all other engineers and causes many plant owners to think that an engineer is one who sits down and lets things run as they will.

A year or so ago I was called in on a repair job that was directly due to a lack of proper appreciation of

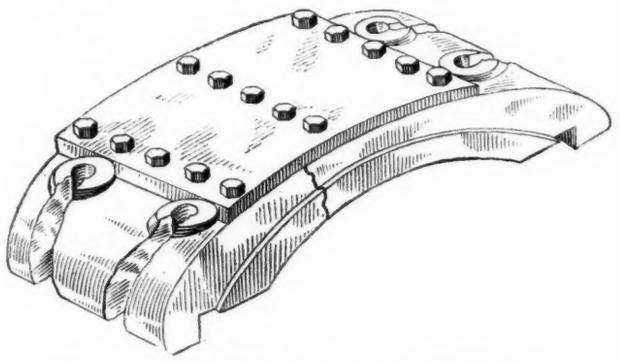


FIG. 1—REPAIR OF BROKEN BEARING CAP

machinery on the part of the operator. The trouble was in an oil-engine plant where the one engine carrying the lighting load of a Western town was shut down owing to an accident. The plant, which was privately owned, was meeting with a lot of ill feeling from the citizens, and there had been for many months a desire for a municipally owned plant. The forced shutdown served to increase this desire, and the management was in a mild panic when I arrived. It was impressed upon me that the engine must be put back into service at once. I was given to understand that speed on my part would help my company a lot toward selling the plant a second engine. The chief owner, a modern Shylock, in order to enlist my best efforts, unbent so far as to offer me a decidedly black cigar.

Upon going to the plant, I found that one connecting rod was bent in the form of a U, two of the main bearing caps were broken, while the outboard bearing was torn away from its base and the extension generator shaft somewhat bent.

The engineer, who was one of those lean, "do-less" fellows, said that the engine just let go, as he called it, when he started it up in the afternoon to carry the night load.

The bent rod was on one of the air-starting cylinders, and so I asked if he had thrown the lever from "start" to "run" before the accident happened. He said not and further claimed that he had not dosed the cylinder with gasolene or kerosene, neither had he put in any lubrication oil. This last is a thing a lot of men do if the compression is poor in order to seal the piston and so prevent air leakage.

The thing to do was to get the engine repaired. I examined the connecting rod and other parts, and recommended that they wire for a new rod and bearing caps. This I knew would mean a wait of a week or two, and so I decided to try to straighten the bent rod and repair the bearings. A railroad machine shop was in a neighboring town, so we lugged over the connecting rod in a jitney and induced the blacksmith to heat and straighten it at once, while I returned to fix the other parts.

The broken bearing caps were examined and found to be hopeless, as both the caps and liners were broken and the plant had no new ones. To find some means of using the old bearing caps was essential if a week's delay was to be avoided. I took the two broken pieces of each cap and after bending a piece of ¼-in. boiler plate to fit the top surface, secured it with ten ⅜-in. capscrews. This held the two pieces together. A series of ½-in. holes were drilled partly through the shell. These were to act as anchors for the babbitt, which was run into the cap without the use of a separate liner. The babbitt, owing to lack of time, was not made small and bored to size. Instead we merely scraped it to a nice surface. The bearing holding-down studs were broken off in the bearing housings, so the lower ends were drilled and backed out. New bolts were made at the railroad shop and set into place. Now the bearing caps were broken out at each bolt hole, and in addition the boiler plate was not strong enough to hold the cap if any great pressure was brought against it. To strengthen the caps, ¾x3-in. iron bars were formed to fit over them and, after being drilled at each end, were slipped over the studs. This enabled us to draw the caps down snug. I was afraid that the bars would not fit down all along the caps, so four ⅜-in. setscrews were placed in each bar and tightened so that their noses pressed against the cap.

The next problem facing us was what to do about the bent extension shaft. The generator rotor had not suffered any damage and the stator was not injured except that a few of the cast-iron coil guards were broken, and the sole plates supporting the generator frame were broken, the side thrust of the shaft and rotor having thrown the generator frame an inch or so to one side.

The kink in the shaft was halfway between the coupling and the rotor, just before the shaft enlarged to accommodate the rotor. To remove the rotor and straighten the shaft would take more time than we could allow. It was decided to take it over to the rail-

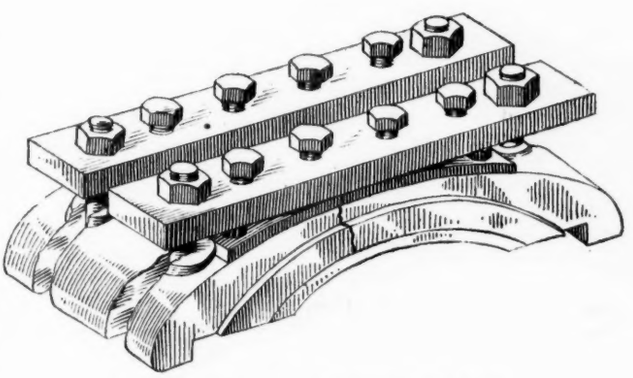


FIG. 2—METHOD OF HOLDING CAP

road shop and, after heating, straighten it without removing the rotor.

At the shop we put the shaft on the big wheel lathe and applied the acetylene torches as it was rotated. When it was as hot as it could stand without hurting the rotor, the lathe carriage was moved in and a 3-in.

steel roller mounted on a holder was pressed against the shaft square with the kink in it. The torches were kept going and the shaft rotating. Gradually, the shaft was worked back into its correct position. Upon testing it was found straight, but the coupling face was $\frac{1}{32}$ in. out of square with the shaft. It was necessary to turn the face and edge of the coupling and to ream the bolt holes again.

The shaft and rotor were placed back into position, the outboard bearing pedestal put into place and the

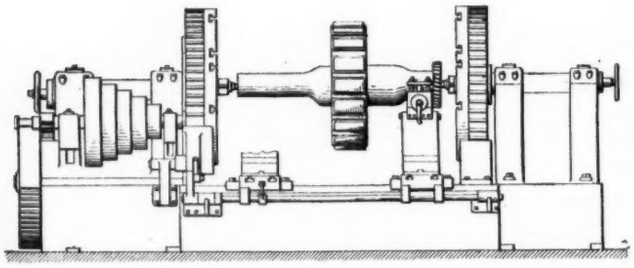


FIG. 3—STRAIGHTENING THE BENT SHAFT

break mended with iron bars and capscrews. The coupling holes were too large for the coupling bolts, but brass sleeves were slipped in to fill the clearance and reamed to accommodate the bolts.

By this time we had the connecting rod back and in place. The blacksmith had left traces of his sledge on the rod, but it was straight, which was the thing desired. We then put the engine parts back into place and leveled the shaft by means of a spirit level, this being the only way possible in the rush.

After turning the engine over by hand a few times to see that all was in working order, the air was turned on and away the engine went and was soon on the line with only four days' shutdown from the day I arrived. Was I played out? Who cared? Such is the life of any trouble man.

Now to find the cause of this wreck. While the repair work was going on, I had two of the helpers grind the valves. I noticed that the air-starting valve had to be driven out of the cage. Upon inspecting the valve, the stem was found to be very rough and was binding in its guide. The engineer offered the information that just before the accident happened, this cylinder had roared as if the starting air was leaking out. I figured that the rocker arm had opened the air valve as usual when starting, but that the valve stem jammed enough to prevent the spring from closing it. The starting air blew into the cylinder during the exhaust and suction stroke. When the suction valve closed, the cylinder was filled with air at 200 to 300 lb. pressure. The momentum of the flywheel forced the piston up against this air pressure and slammed the air valve closed. The result was a high cylinder pressure due to this compression—maybe as high as 2,000 lb. At least it was enough to bend the connecting rod and do the rest of the damage.

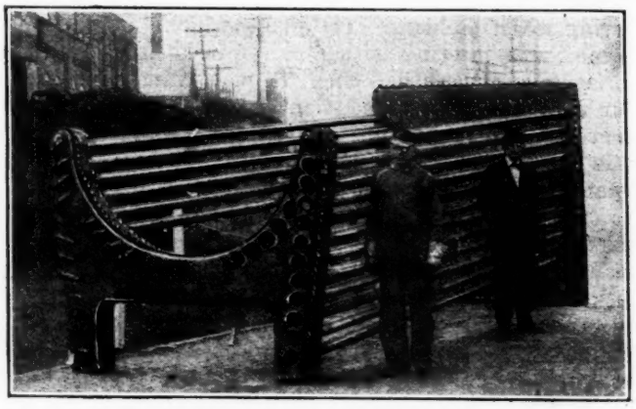
The engineer should have noticed, when inspecting the valve, that the air valve was binding. In addition he had opened up all three air receivers to start upon instead of using only one. With a single air receiver on the line the loss of air during the exhaust and suction strokes would have caused the air pressure to drop to practically zero gage and there would have been no damage.

Mitchell Waste-Heat Economizer

A water-tube element for insertion in the furnace of a horizontal return-tubular boiler, to add to the steam-making capacity by improving the circulation and exposing additional heating surface to the radiant energy of the fire, to absorb heat that would otherwise be radiated from the setting and to protect the brickwork, has been designed by the Mitchell Boiler and Engineering Co., of Mitchell, Ind. As shown, the element consists of front and rear box headers spaced apart the length of the setting, with interconnecting tubes pitched upward toward the rear to insure circulation. The tubes are arranged in a vertical row on either side along the side walls and also occupy a portion of the semi-circumference underneath the boiler shell. As with any water-tube boiler, they are rolled into the tube sheets of the headers and access is given through handholes in the outer sheets of the header.

From the top of the rear header two connections are made to the boiler just below the water line. At the front, two connections drop, one on either side of the header, to a point near the bottom of the water leg. In addition to the regular boiler blowoff, two blowoff connections are made near the bottom of the rear header. Through one of these blowoff pipes the feed water is introduced.

To install such a unit, the boiler front and the front arch are taken down and the rear wall removed. The headers are placed in position, the tubes are rolled tight into the headers and the connections are made to the boiler. The boiler front is then replaced and a



MITCHELL ECONOMIZER UNIT AS VIEWED FROM THE FRONT

thin wall built up at the rear, so that the entire unit is invisible except for the handhole plates. All material and details of construction conform with the A. S. M. E. Boiler Code.

It is evident that the furnace is surrounded by water surface exposed directly to the radiant energy of the fire, and so placed as to protect the brickwork without cutting down to a noticeable extent the furnace volume. This surface should be particularly effective, and while the temperature range between gas and water in the boiler is reduced, the steam-generating capacity of the unit should be increased. On such a basis it should be possible to cut down the number of boilers to carry a certain load, with the resulting economies, or for increased capacity the installation of new boiler units may be obviated.

Extending the Life of Large Waterwheel Runners at Small Expense

By Guy L. Bayley*

The hydro-electric plant of the Cohoes Power & Light Co., on the Mohawk River, at Cohoes Falls, N. Y., was put into operation in 1915. Three vertical-shaft single-runner Francis-type turbines, each having a normal rating of 10,000 hp., operating under an effective head of 96 ft. and full-gate opening, comprise the main equipment. After seven years' operation inspection showed that pitting had taken place on the backs of the runner blades to such an extent as to cause holes to be corroded completely through them, as indicated in Fig. 1.

This form of pitting is generally found on the backs of cast-iron propeller blades, although its occurrence is not uncommon in cast-iron turbine runners which were designed without a due appreciation of the proper shaping of the blades. The corrosion results from a failure of the flowing water to follow the curvature of the blade, thus forming a partial vacuum which extracts oxygen from the water, and the action of this oxygen causes the metal of the blade to corrode.

The runners in this instance are 75 in. in diameter measured at the mid-point between hub and bottom, and weighed 7½ tons each. To have replaced them would have caused delay and been expensive. The final decision was that a successful repair could be made by electrically welding patches into the holes and building up the corroded areas with new metal welded on by the electric-arc method. The first step was to chip off the spongy metal from the corroded surfaces. Owing to the uncertainty of the bond between the new metal and the old and the strains that would result if the blades were heated insufficiently to effect a good weld, no reliance for strength was placed on the bond. When the runner is operating at full speed, the forces tending to remove such additions to the blade are considerable. To meet these conditions the affected blade areas were drilled and tapped for ⅞-in. stud bolts set on 1-in. centers. The bolts were cut 2 in. long and the extra length trimmed off after the building-up process was completed. It required 2,400 of these stud bolts for one runner. The holes in the blades were fitted with patches made of boiler plate, the edges of which were welded to the blades. In the process of building up the metal to the original blade surface, the arc was worked back and forth along the lines of stud bolts, each time making a positive weld to each bolt. By the exercise of considerable skill and great care on the part of the welder, each corroded area was built up with a homogeneous mass of pure iron which inclosed the boiler-plate patch and was held firmly by the stud bolts. The welding left a rough surface, which was finished, as in Fig. 2, by means of a portable electric grinder operating a 4-in. wheel.

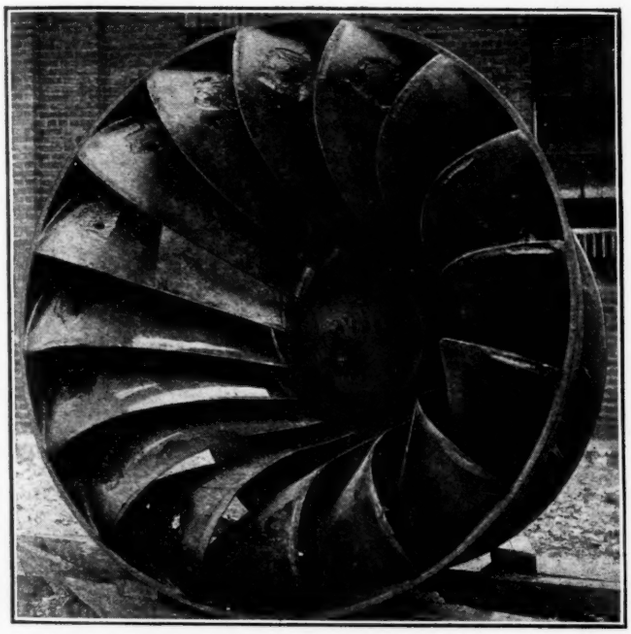


FIG. 1—CONDITION OF ONE RUNNER'S BUCKETS BEFORE BEING REPAIRED

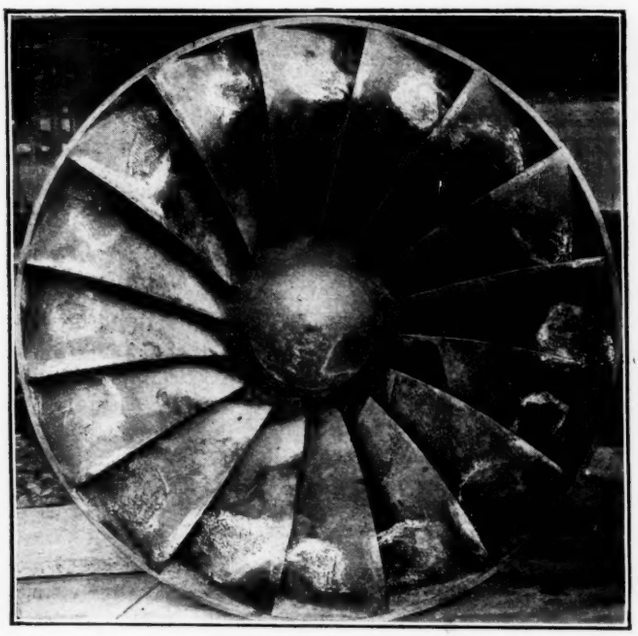


FIG. 2—TURBINE RUNNER AFTER BUCKETS HAD BEEN REPAIRED BY WELDING

When the repaired runners were put into service, they developed their original capacity, and it is expected that several more years of useful life will be obtained, after which they will be replaced by runners designed to avoid such trouble. The work was done under the supervision of Sanderson & Porter, New York City, engineers for the Cohoes Power & Light Co.

*Sanderson & Porter, Engineers, New York City.

The voltage of a rotary converter cannot be varied by simply varying the field strength as in the ordinary direct-current generator. It is necessary to provide some means for changing the applied alternating-current voltage which can be accomplished in a number of ways, such as bringing out a number of taps from the transformers, shunt-wound converters with induction regulators, compound-wound converters with reaction coils, regulating-pole converters, and series-booster converters. The latter method is used extensively on machines of large capacity.

The Action of the D Slide Valve

An Explanation of the Effect of Lap, Lead and Angle of Advance—Simple Diagrams Showing How the Valve Action May Be Studied Graphically.

VARIOUS methods of showing the action of the *D* slide valve have been devised, most of them including the construction of somewhat elaborate diagrams. A simple method, however, may be employed for all ordinary cases, only the most elementary of diagrams being used.

Suppose the eccentric throw is 4 inches. With a direct connection from eccentric to valve the travel of the latter would be 4 inches. We will then construct a circle 4 inches in diameter with its center at O. Next a port is drawn to the right of the center of the circle equal to the width of the head-end steam port of the engine, Fig. 1*A*. If there is no steam lap and no lead, the eccentric will be at *e* in midposition and the edge of the valve will just cover the port edge when the engine crank is at head-end dead center at *d*, the circle representing to scale the crank-pin travel. The valve travel from midposition toward the crank end will be *oc*, or one-half the eccentric travel, and the travel from midposition toward the head-end will be *od*. The valve will not only uncover the head-end valve port *ov*, but will travel beyond it the distance *bc*. On the return the valve passes the edge of the steam port at *o* and continues to *d*, *od* being the overtravel of the valve.

Valve Position with Lap.

Assume now that we have a steam lap *of* as in Fig. 1*B*. Then if the steam is to be admitted when the crank is at dead center at *d*, the valve must be in the position shown. The eccentric will be displaced from the midposition *e* shown in Fig. 1*A* an amount such that the valve will have moved the distance *of*, when the engine crank reaches dead center at *d*, the eccentric position will then be *f'*. Drawing the line *of'* on the valve circle gives the angle *eof'* through which the eccentric must be shifted from its position of 90 deg. ahead of the crank-pin to have admission take place at dead center.

If the engine is to have lead, the valve must uncover the port an amount equal to the lead, made equal to *ov* in Fig. 1*C* when the piston is at *d* or dead center. The eccentric must be shifted so that it is in the position *f'*, Fig. 1*C*, when the crank is at dead center. Cutoff will take place when the valve moves to the end of its travel to the right at *c*, and reversing moves to the left until it covers the port. The eccentric during this time moves from *f'* to *f''*. Now the eccentric is ahead of the crank by an amount measured on the valve or eccentric circle equal to the arc *df'*. To find the crank position when cutoff takes place and the eccentric is at *f''*, it is merely necessary to lay off backward from *f''* the chord *f''h* equal to *df'*, giving the cutoff position of the crank at *h*. The valve, after cutting off the flow of steam, continues toward the left to the end of its travel at *d*, and when the eccentric is at mid-position *e'*, the valve starts to open

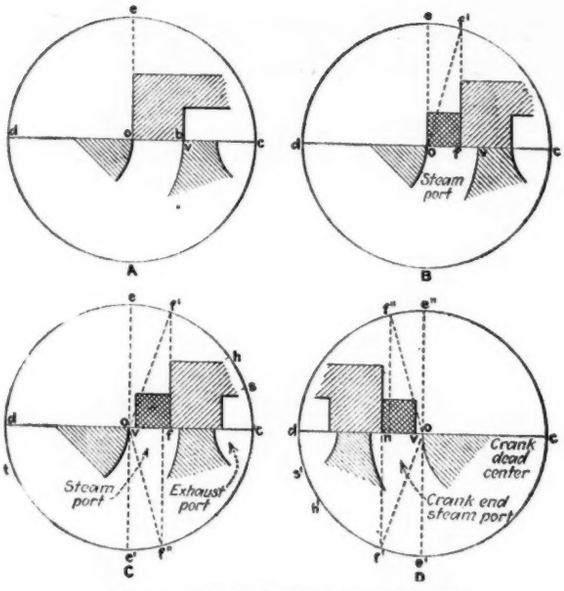


FIG. 1—ACTION OF D SLIDE VALVE

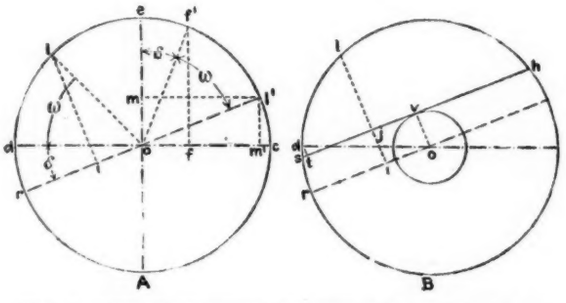


FIG. 2—DEVELOPMENT OF THE VALVE DIAGRAM

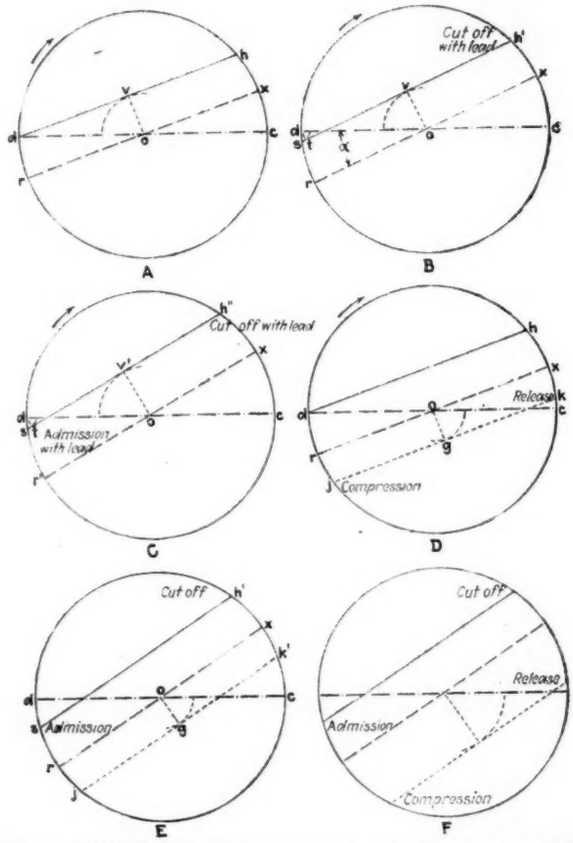


FIG. 3—FINDING LAP, LEAD AND ANGLE OF ADVANCE

the passage to the exhaust port. The crank position when the exhaust passage is uncovered is found by measuring back from *e'* an arc equal to *df'*, this being the amount by which the eccentric is ahead of the crank. The crank is found to be at *s* at release. Compression takes place after the valve has traveled to the left to *d*, reversed, and covered the exhaust port. The eccentric

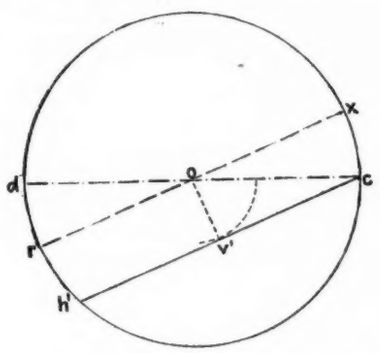


FIG. 4—CUTOFF AND LAP FOR CRANK END

during this time continues past dead center at *d* and reaches mid-position at *e*. Measuring back from *e* an arc equal to *df'*, or *f"h*, we find that compression in the head end occurs when the crank is at *t*.

Obtaining the Crank-End Events.

The events for the crank-end may be obtained by drawing on the same or on a separate circle the crank end of the valve remembering that the angle of advance *eof'* has already been determined. Next from the crank dead center point *c* lay off *cf'* equal to *df'* for the head end, for the angle of advance has been fixed by the head-end diagram, and the angle *e'of'*, Fig. 1*D*, must be equal to the angle *eof'* in Fig. 1*C*. We now have the eccentric position when the crank is on crank dead center, or in other words the location of the edge of the valve without the lap is found by erecting a perpendicular line from *f'* to the valve travel, giving *n* as the position of the valve. If the lead *ov* is to be the same as for the head end, then *vn* is the crank-end lap required to give the same lead as on the head end.

The point of crank-end cutoff *h'* is found by measuring from *f"* an arc equal to *cf'*. Release would be found by measuring from the eccentric mid-position *e"* giving *s'*.

In Fig. 2*A* we have a valve diagram with the eccentric center line falling along *of'* when the crank is at dead center *d*, this being the same as in Fig. 1*C*. Now the valve is off its center position the distance *of* when the crank is at dead-center position at *d*, this distance being made up of the lap and the lead as in Fig. 1*C*.

Now suppose that the crank is turned through the angle ω until it is in the position *l*. The eccentric will also turn through the same angle ω, putting it into the position *l'*. The valve is now displaced from its mid-position *o* a total distance equal to *l'm* or *om'*. This distance equals the lap and lead plus the port opening and overtravel *fm'*.

Now draw the line *or* so that the angle *dor* is equal to the angle of advance δ or the angle *eof'*. Next drop a perpendicular line *li* from the new position of the crank *l* when the crank has moved through the angle ω. Now *li* is equal to the valve displacement *l'm*. That this is true is proved by the fact that the angle *lor* is equal to the augles $\delta+\omega$ or the angle *ol'm'*, and the angle *l'm'o* is equal to the angle *lio*, both being right angles. The side of *ol'* is equal to *ol*, both being radii of the circle. It follows that the two triangles are equal. This being true, the side *li* is equal to the valve displacement *om'*.

By dropping a perpendicular line from any crank position upon the line *or* drawn so that the angle *dor* is equal to the angle of advance *eof'*, we find at once the amount the valve is displaced from its center position for any crank displacement angle ω.

If now, as in Fig. 2*B* a circle with a radius *ov* equal to the valve lap be struck with *o* as a center and a line *sh* be drawn parallel to *or* and touching the lap circle at *v*, then *lj* represents the amount of valve opening when the crank is in the position *l*, for *li* represents the valve displacement and if *ij* (being equal to *ov*) is the lap, *l'* must be the port opening. The distance *dt* represents the amount of lead or the valve opening when the crank is at dead center. The point *h* is the crank position when the valve has returned and just covered the steam port, or the point of cutoff.

The simple diagram may be used to show the effect of increasing the lap or of increasing the lead. To illustrate, let us construct a circle with *o* as the center and with a diameter equal to the valve travel as in Fig. 3*A*. The circle also will represent to some scale the crank circle. Suppose the engine is to take steam when its crank is at *d*. If cutoff is desired when the crank is at *h*, draw the line *dh*. Then strike an arc with a radius equal to the perpendicular distance from *o* to the line *dh*, or *ov*. The distance *ov* is then the lap necessary to have the engine cutoff at *h* with admission at dead center.

To find the angle of advance draw *rx* through the center *o* and parallel to *dh*. The angle *dor* is then the angle of advance as proved in Fig 2*A*.

Suppose, now, it is desired to give the valve lead amounting to *dt*, Fig. 3*B*. Lay off an arc with *dt* as the radius and *d* the head-end dead-center point as a center.

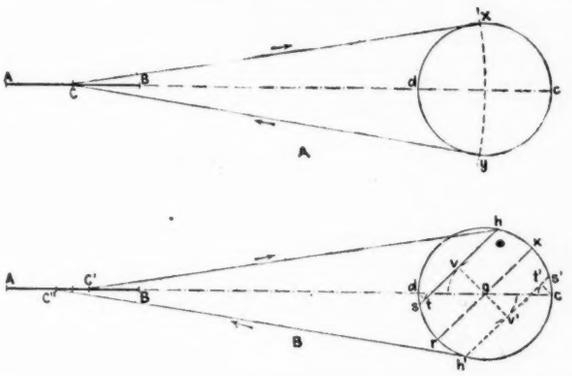


FIG. 5—EFFECT OF CONNECTING ROD ON VALVE ACTION

With the lap *ov* as a radius strike an arc with *o* as a center. Draw the line *sh'* tangent to these two arcs. Cutoff will then take place at *h'* and admission at *s*. The angle of advance is found by drawing the line *rx* parallel to *sh'*, giving the angle of advance as *dor*, Fig. 3*B*.

If the lap is increased to *ov'*, as in Fig 3*C*, while the lead is kept the same as in Fig. 3*B*, cutoff will take place earlier at *h"*. The angle of advance is also greater than before, being *dor'*.

Turning now to the exhaust events, if there is no exhaust lap and no angle of advance, the exhaust port would open at dead center and close at dead center. Shifting the eccentric ahead of its midposition when the

crank is at dead center—that is, giving it an angle of advance—causes the valve to uncover the exhaust port before dead center and likewise to close it before dead center. With the angle of advance *dor* as given in Fig. 3*A* and with no exhaust lap the head-end exhaust port is uncovered; that is, release occurs when the crank is at *X* Fig. 3*A*, and the exhaust port is closed, or compression begins when the crank is at *r*.

Now suppose the valve is given exhaust lap *og* Fig. 3*D*. An arc is struck about *o* as a center and with a radius *og* equal to the exhaust lap. The line *jk* is then drawn parallel to *rx* where the angle *dor* is equal the angle of advance required for the desired steam-port events. The point *k* is the crank position for release and *j* the crank position for compression when the angle of advance is *dor* and *og* is the exhaust lap.

Increasing the angle of advance in order to give lead will make release and compression earlier, as shown in Fig. 3*E*. Increasing the inside lap will make release later and compression earlier as shown in Fig. 3*F*.

We find, then, that increasing the angle of advance will make admission and cutoff earlier and will also make release and compression earlier.

Giving more steam lap will cause admission to be later and cutoff earlier.

Giving more exhaust lap will bring release later and compression earlier.

In this discussion only the head end has been taken up. The events for the crank end may be found from the same kind of diagram. The angle *dor* in Fig. 3*A* is the angle of advance as is also the angle *cox*.

If, now, the crank end is to have no lead and the angle of advance has been fixed as *dor* in Fig. 3*A*, we can draw the line *ch* in Fig. 4 parallel to the line *rx*. This makes the crank-end cutoff occur at *h'* and the crank-end steam lap is *ov'*.

If the crank-end has lead, the crank-end steam lap must be less and crank-end cutoff will be later than shown in Fig. 4. It will be seen that the two sides of the valve are by no means independent of each other. For the crank-end exhaust events the lines are drawn above the line *dc* and opposite to the locations of the head-end exhaust events.

Angularity of Connecting Rod

No mention has been made of the effect of the angularity of the connecting rod. This affects the position of the piston in the cylinder relative to the crankpin position. As outlined in Fig. 5*A*, when the piston moves from *A* to *C*, or one-half the stroke, the crankpin moves from *d* to *x*, less than one-quarter the crank circle. On the other hand, when the piston moves from crank-end dead center to *B* to the middle of the stroke *C*, the crank moves from *c* to *y*, this being more than a quarter of the crank circle.

For this reason if cutoff were to take place when the crank was at its midpoint, the piston on the head-end stroke would be beyond *C* the midposition, while on the crank stroke when the crank was in its midposition, the piston would not have reached *C*. If cutoff is to take place on both ends when the piston is in the middle of its stroke, the cutoff position of the crank for the head end is ahead of crank midposition and is after midposition for the crank end. The steam lap, then, for the head end must be larger than for the crank end if the cutoff position of its piston is to be the same for both ends. In using a valve diagram this angularity effect of the rod must be taken into account.

For example, in Fig. 5*B* suppose it is desirable to have both cutoffs occur at ⅞ stroke, at *C'* for the head end and at *C''* for the crank end. To locate the head-end crank position for cutoff, strike an arc from *C'* with the connecting-rod length *Ad* as a radius; this gives the point of cutoff at *h*. If *dt* is the necessary lead to cause the engine to run smoothly, this is laid off from *d* as shown. The line *sh* is then drawn from *h* tangent to the arc having *dt* as a radius. The head-end steam lap is then *ov*. The angle of advance is *dor*, found by drawing *rx* parallel to *sh*.

Next the position of the crank for crank-end cutoff at *C''* is found by striking from *C''*, giving the point *h'*. The line *h's'* is drawn parallel to the angle of advance line *rx*. The crank-end steam lap is *ov'*, smaller than the head-end lap *ov*. It will be noticed that the crank-end lead *ct'* is larger than the head-end lead *dt*. This means that for equal cutoff the crank-end lap must be less than the head-end lap and that the crank-end lead will be greater than the head-end lead. If *dt* is as much lead as is needed to admit steam promptly *ct'* may be too much lead, although the crank end of many vertical engines is given slightly more lead than the head end.

In setting ordinary slide valves one has to choose between these two conditions, either equal cutoffs and unequal leads or equal leads and unequal cutoffs. Usually, the leads are made equal, causing the crank-end cutoff to be earlier than the head-end cutoff.

A study of the diagrams will show one that to obtain equal amounts of compression the crank-end exhaust lap should be larger than that for the head-end in order to cover the exhaust valve earlier, as is required by reason of the angularity of the connecting rod.

In the table below are shown the ways the various events are affected by changes in the valve, etc.

	Increasing Steam Lap	Increasing Exhaust Lap	Increasing Travel	Increasing Angle of Advance
Admission	Later	Not Changed	Earlier	Earlier
Cutoff	Earlier	Not Changed	Later	Earlier
Release	Unchanged	Later	Earlier	Earlier
Compression	Unchanged	Earlier	Later	Earlier

Characteristics of Oil Shale

Good oil shale resembles hard, dark wood or even leather, and an experienced worker can determine its quality by the readiness with which it curls when cut with a sharp knife, states Martin J. Gavin, refinery engineer, in Bulletin 210, recently issued by the Bureau of Mines. This property and its color, weight and streak, enable it to be distinguished from the "blaes," although the latter often pass or grade into an oil shale yielding enough oil and ammonia to be worked profitably.

Scotch shale operators distinguish plain and "curly" shale, the former being flat and smooth and the latter contorted and polished or slickensided on the squeezed faces; the same shale may be partly plain and partly curly; the curly shales often, but by no means always, yield more oil than the plain shales. However, curly shales always yield well, as only a reasonably rich shale curls under lateral pressure.

Don't run an ammonia compressor excessively hot or ice cold; either way means loss of efficiency. Usually, the best results are had when the discharge pipe is just hot enough to bear the hand without burning it. Don't circulate water in the cylinder water jackets if the water coming out of it is not warmer than that going in.

EDITORIALS

F. R. LOW, EDITOR

Fuel Oil in New England

EACH of the periodic disturbances in coal supply during the last few years has furnished a more or less temporary stimulus to the use of fuel oil. As a result of the latest interruption, however, fuel oil seems to have gained a permanent foothold in New England and is still increasing in favor, not only for power boilers in industrial plants, but to a large extent for low-pressure heating boilers in apartment houses, office buildings and even private residences.

The desire of owners to be relieved of the worries incident to recurring coal shortages has led many to take advantage of the long-term contracts now being offered by several of the oil companies at fairly reasonable prices.

The price of fuel oil is governed to a large extent by the demand for gasoline, inasmuch as the greater the production of gasoline the greater will be the supply of fuel oil as a byproduct. The number of automobiles continues to grow yearly, hence the outlook points to an increasing demand for gasoline, with an ever increasing supply of fuel oil unless, perchance, research finds a way to convert a still larger percentage of the crude into gasoline.

Of course the demand for marine use is another factor, although not appreciable at present; also the price of coal, although there is no general basis of comparison with coal on account of local conditions often introducing controlling factors. How far inland fuel oil can compete with coal is a matter of transportation charges.

Mexican crude has fallen off to some extent, but this has been offset by increased production in California, and much of New England's supply is now obtained from the latter fields by shipping through the Panama Canal.

Squaring the Circle

THE mathematician has bequeathed to the engineer along with methods that are priceless, the impractical idea that the correct answer to a problem is of no value unless it is obtained in accordance with a certain set of rules. Possibly this point of view is all right for the mathematician who, by closing all other avenues of approach, must force himself to develop his own science to the limit. But the engineer is not, as a rule, trying to develop the science of mathematics. What he is after is a certain answer, and it is his business to get that answer with the least expenditure of time and energy. If he is thoroughly practical, he takes the easiest way, whether it be pure mathematics, a slide rule, an engineering handbook, a catalog, asking the fellow who knows or making a simple experiment.

As soon as one throws away all artificial and academic limitations, the ways of getting a result multiply astonishingly. The mathematician says the circle cannot be squared, meaning that there is no theoretically exact method of drawing a square of the same area as a given circle. Practically, it is no trouble at all to square a circle to any desired degree of accuracy. In the same way a circle can quickly be divided into any number of equal parts, regardless of what the geometries may teach. The man who has forgotten all his mathematics need have no trouble in finding the center of gravity of any area. He has only to cut it out of cardboard and balance it on a knife edge. Volumes and areas can be found in other ways than by direct measurement and computation. If no tables or slide rules are available and the cumbersome methods of arithmetic have been forgotten, square roots and cube roots can be extracted by a process of "try and fit," intelligently directed. All kinds of difficult problems in trigonometry can easily be solved by anyone who can handle a tee-square, scale and triangle.

Enough illustrations have been given to prove that "there is more than one way to kill a cat." The engineer who, while gladly taking all the mathematician has to offer, will free himself from artificial restrictions, will rarely find it impossible to get the answer he is after.

Safety Precautions in the Power Plant

ONE of the important problems in the operation of a power station is the protection of men and equipment, and the most difficult part of this problem is protecting the workmen. Devices can be installed to protect the equipment, and if given a reasonable amount of intelligent attention, they can be relied upon to function properly and fulfill the purpose for which they were installed. In a large percentage of the cases where protective devices have failed, the fault has been with the human element making them inoperative. It is difficult to prevent a person from doing some of the inexplicable things that at times have been done and that have resulted in fatal accidents. The fact is, they cannot be entirely prevented, but the introduction of proper safety methods and care in selecting plant attendants will reduce such occurrences to a minimum. The characteristics of the attendants should be carefully studied, and if any are found to be careless, they should be dismissed—for their own safety as well as that of others.

The leading article in this issue describes a system of protecting employees in hydro-electric plants by systematically reporting workmen on or clear of equipment taken out of service for inspection and repairs. The importance of directing attention to the matter of properly protecting men cannot be too strongly emphasized, since in no other way can the safety of the workmen be assured to a high degree. First-class service cannot be rendered by a station in which the men are permitted to work on equipment improperly protected.

Besides the desirable factor of safety introduced when men are systematically reported on or clear of properly protected equipment, operating men will carry out their duties with increased efficiency and dispatch in a station

where suitable safety rules are enforced. As might be expected, it has been found that where equipment out of service is not properly protected by a so-called safety card and signs, or other adequate means, confusion, unnecessary delay, and accidents are very likely to result, even during periods of normal operation, because of the possibility of attempting to use inoperative equipment or equipment on which men are actually at work. In general, owing to the greater amount of equipment required and the number of men employed in a large station, more attention should be directed toward safety measures there than in a small station, and although the system referred to is more suitable for large stations, many of its features will be found applicable to small-station operation.

This system of affording protection is based on the fact that all apparatus or equipment not covered by a safety card or safety signs is known to be in immediate readiness for continuous, reliable operation, hence no doubt can exist as to which equipment is available for use. This feature is important not only as a safety measure, but as a means of maintaining high operating efficiency. Of course appreciable time is required to clear apparatus, place the safety devices and fill out the cards described, but it has proved profitable and advisable to devote this time toward the prevention of accidents rather than practically to invite them by using more rapid methods requiring the observance of less caution.

Reheating Cycle Utilized for Increasing Turbine Efficiency

AS POINTED out by S. Z. de Ferranti, an appreciable gain in turbine economy may be realized by continuous reheating of the steam during expansion, so that an isothermal curve is obtained instead of an adiabatic. Commercial costs have hindered the adoption of such a cycle. A modification of this idea, by which the steam may be reheated at one to three points of expansion to approximately initial temperature, would indicate a slight gain—in the neighborhood of one per cent—for present-day steam conditions. On account of adding heat at high temperature and using this at low pressures, the theoretical economy is too low to be commercially attractive in itself.

The fact that a forty-thousand kilowatt turbo-generator employing reheating has recently been contracted for by the Commonwealth Edison Company for use in the Crawford Avenue Station, as announced in *Power* of Jan. 16, indicates, however, that such a cycle is not dead commercially. In spite of the disadvantages as before mentioned, it has also been pointed out that an appreciable gain may be expected from the elimination or restriction of moisture that otherwise exists in the lower pressure stages, due to decreased friction losses.

While this advantage has been admitted at various times, there is a noticeable scarcity of published information regarding the exact extent of such gains. From the fact that approximately one-half of the work in a modern large unit is produced from the point where condensation begins to appear, to the exhaust containing in the neighborhood of fourteen per cent moisture, it can readily be seen that the elimination of water would represent an appreciable gain and the substitution of superheat would be expected to improve matters further.

Very little is known regarding results of reheating at the North Tees Station in England where steam at four hundred and seventy-five pounds pressure and over seven hundred degrees F. total temperature is used. Reports indicate that mechanical troubles were encountered and that a rotor unusually long between bearings has been partly responsible. The Commonwealth turbine is being built by C. A. Parsons & Co., Newcastle upon Tyne, England, while Merz & McClellan, of London, England, are advisory engineers. Since Merz & McClellan, were also employed in a similar capacity with regard to the North Tees Station, it is probable that the lessons learned there will result in interesting improvements. The new units, as reported, will be of forty-thousand-kilowatts capacity, operating at five hundred and fifty pounds, seven hundred and twenty-five degrees F. total temperature.

Owing to the comparatively small size of a high-pressure unit, such as for conditions of one thousand pounds, eight hundred degrees F., expanding to a convenient pressure, that would prevent condensation, it would be interesting to consider such a machine placed close to a high-pressure boiler, connected by small pipes and exhausting into a superheater for supplying a low-pressure unit. The cross-compound principle of construction and inter-relation with the boiler as a unit may present interesting developments when higher pressures are successful.

The Future of Shale Oil

THE Bureau of Mines, in co-operation with the State of Colorado, has issued a 200-page bulletin on oil shale. The author, Martin J. Gavin, has considered the subject from the historical, the technical and the economic viewpoints.

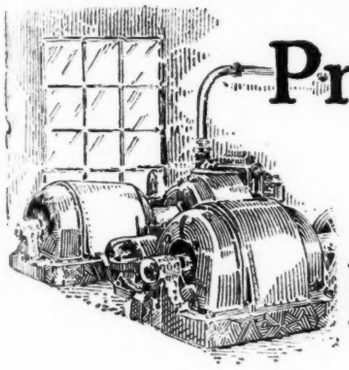
The bulletin is published at a most opportune time. The consumption of petroleum products in the United States exceeds production, the difference being taken care of by imports from Mexico. This indicates that the time is approaching when petroleum imports must be increased or some other fuel must be used as a substitute for gasoline, etc. This situation, coupled with the enormous profit made each year by the petroleum refiners, has enabled optimistic promoters to flood the country with shares of shale-oil companies. In many cases these projects are fraudulent, others are based on too optimistic hopes of honest men, while a few appear to have some basis of eventual success.

Upon reading this bulletin, one finds that oil-shale mining and retorting is by no means new. Not only has it been carried on for almost one hundred years in Scotland and France, but in 1860 retorts were in operation in the United States.

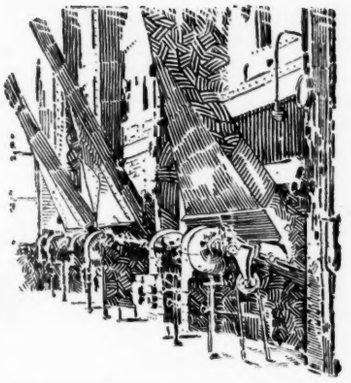
Apparently, as long as shale oil had no competitor, it could be manufactured with profit. With the development of the petroleum industry and the consequent lowered price of oils, the oil-shale refineries could not exist. Even in Scotland, where the petroleum oils command higher prices than prevail in America, the shale oil companies have barely been able to operate.

Experiments with small refineries indicate that oil shale cannot be mined and refined at cost equal to the selling prices of petroleum products.

The conclusion may be made with considerable degree of confidence that oil shale cannot be handled profitably as long as petroleum prices are as at present. Only by the exhaustion of the petroleum fuels may the purchasers of most oil-shale stocks hope to see the fancy engraved certificate become other than a scrap of paper.



Practical Ideas *from* Practical Men



Flow Meter on Condensate Discharge Indicates Blading and Gland Trouble in Steam Turbine

A few years ago the Baltimore County Water and Electric Co. installed a turbine-driven pump to deliver 2,100 gal. of water per minute under 712 ft. working head, and one of the features in connection with the condenser equipment was a metering hotwell of the indicating type, which, of course, had to be read frequently.

To obtain a continuous record, a combination was worked out to utilize a recording flow meter of the balancing type in connection with the metering hotwell.

A study of the condensate discharged showed that without regard to the load on the steam turbine the amount of water condensed varied continually within certain limits, owing to the variation in the degree of superheat as well as the load, and in our case, when trouble developed in the labyrinth packing between stages, we noticed an increase in the water rate before any other trouble was noticeable. Later, there was vibration at certain stages. This required attention and when remedied the water rate dropped to normal again. Similar indications were observed when some of the vane tips in the turbine pump broke off and damaged the wearing rings on the impellers, causing increased leakage between stages.

A device of this kind may be utilized either with a tube, venturi throat or an orifice, and will indicate turbine trouble, such as loss of blades in the rotor, stage leakage, etc., before it is noticeable otherwise, and when compared with charts from a graphic wattmeter, a record of this kind gives the central-station operator a valuable record for comparison. A. E. WALDEN.

Baltimore, Md..

Muriatic Acid Effective in Removing Scale from Pipes

There are few, if any, power plants that do not have more or less trouble with accumulations of scale in the hot-water lines comprising the various systems. For years it had been our practice to renew sections of lines when they had become plugged to such an extent that the flow was impaired and the line failed to deliver up to capacity. This necessitated the taking down of the line in sections, first removing the pipe covering, cleaning it out by various mechanical means, then replacing it and following up with the covering again.

A short time ago we had trouble getting water into the boilers. An examination of the top feed-water header disclosed the trouble. The 6-in. line had been constricted with scale so that at the worst points there was only about a 1¾-in. opening. The bottom header was not in much better condition, and immediate renewal of both lines was considered necessary. These two lines supply a battery of ten 4,500-sq.ft. boilers. A rough estimate of the cost for replacing the lines amounted to about $2,000 including the covering.

As an alternative the following method was used with such satisfactory results that it can be recommended to those having similar scale formations. The scale was purely a carbonate of lime formation and an analysis gave the following compositions: Silica, 1.24 per cent; oxides of iron and aluminum, 0.77; carbonate of lime, 80.4; magnesia (MgO), 4.57; sodium and potassium sulphates, trace; oil, 2.90; moisture and organic matter other than oil, 9.38; undetermined matter 0.74 per cent.

A sample of the scale was found to be readily soluble in muriatic acid, so it was decided to try and dissolve the scale out of the line. A hogshead was placed close to a spare boiler-feed pump and connected to the suction line of the pumps by a 2-in. pipe. The drain on the other end of the feed-water line was connected to a 2-in. loop extending three feet above the line and carried back to the hogshead. The feed-water line was then cut out of service for cleaning. The hogshead was filled a little more than one-third with water and an equivalent amount of 18 per cent muriatic acid poured in. The pump was started slowly and the dilute acid pumped through the feed-water line and returned to the hogshead. The chemical action starts at once, as is indicated by the gas and almost black discoloration of the returning acid. Raw acid is added as is necessary and as the action becomes less lively .

The pumping was continued for twenty-four hours, and at the end of that time an examination of the line showed that the scale was softening perceptibly and had begun to dissolve along the bottom. An analysis of the scale now showed about the same results, except that there was an increase in the oil content of about 4 per cent. This was to be expected, as a high percentage of oil serves to neutralize the acid.

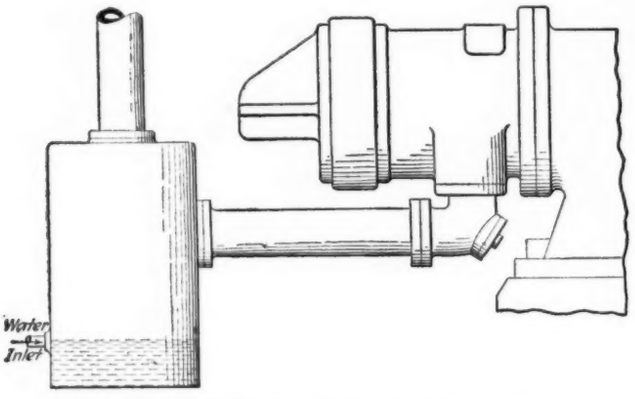
The pumping was continued for another period of twenty-four hours and an examination of the line showed that the scale had been cleaned to the metal at several points along the bottom of the line. An analysis of the scale indicated a still further increase in the oil content, which was now as high as 10 per cent. The pumping was continued for another twenty-four hours and an inspection showed that the line was thoroughly cleaned to the metal all the way around. This line was immediately washed out and put into service and the bottom feed line connected up for cleaning. About twenty carboys of acid was used on each line.

So far there has been no bad effect from the action of the acid. It did not affect gaskets, pump valves or pump and had little effect on the pump packing. This method of cleaning cost about $400, which netted us a saving of some $1,600 over the old method of taking the lines down and cleaning them out. Further, the fittings and pump were thoroughly cleaned out, better than could be done by hand. H. M. TOOMBS.

Chicago, Ill.

Some Experiences with a Hot-Bulb Oil Engine

A considerable amount of fuel oil failed to burn in the cylinder of a semi-Diesel oil engine and dripped out through the exhaust ports. This was troublesome in two ways—it caused carbon to form in the exhaust



ARRANGEMENT OF EXHAUST PIPING

ports, and it accumulated in the exhaust pot and eventually caught fire. The carbon in the exhaust ports had little effect until two of the three ports were entirely clogged. It then made itself felt by the engine refusing to carry full load, and by heavy black smoke, although operation on low loads would be normal.

This made necessary the frequent cleaning of the ports. To do this, the exhaust elbow was removed, and a man on his back under the cylinder poked upward with a sharp bar.

The oil that was forced over into the exhaust pot gave us serious concern. Under continued heavy loads the engine explosions would begin to have an odd muffled sound. White smoke would appear at the exhaust stack and sparks would begin to fly. Finally, a flame several feet long would start from the top of the exhaust stack, like a gas torch, and roar continuously. The engine would slow down, and chunks of blazing carbon would rain over the neighborhood. As this invariably occurred on the peak load, it was annoying as well as dangerous. We resolved to operate without stopping, and to that end a hose was turned onto the outside of the exhaust pot. This helped somewhat. A man was then placed on the roof, and sent a stream of water down the stack. This was better, though much of the water was immediately blown out as steam, doing no good and scalding the man.

We asked the engine builders about putting water in the exhaust pots, but they advised against this, saying it would cause corrosion due to the formation of sulphuric acid. Nevertheless, water was piped directly into the exhaust pots. This never failed to prevent or stop the fire. No corrosion trouble was ever noted. The use of water in the exhaust pot seemed to have a marked effect in reducing the formation of carbon in the exhaust ports.

Investigation indicated that this carbon and oil in the exhaust came from two sources. By reason of a change to an unsuitable lubricating oil large amounts of this oil was necessary in order to keep the pistons from sticking. Much of this drained to the crankcase, where it was more or less mixed with the scavenging air. When the piston uncovered the air-transfer port, this oil was blown into the cylinder and out through the exhaust ports. A second source was the fuel oil. On heavy loads the temperature of the piston crown became excessively hot. The oil spray entered the combustion chamber at a point in line with the cylinder axis. Part of this fuel sprayed onto the piston crown. As soon as it struck the red-hot metal, "cracking" occurred, with the creation of carbon deposits and a heavy tarry hydrocarbon that refused to burn.

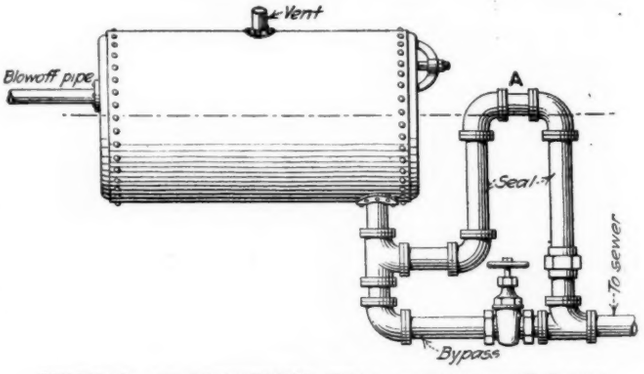
By changing the grade of lubricating oil, the lubricating oil portion of the deposit was eliminated. Carrying a colder cooling-water temperature caused the rate of heat transfer from the piston to the cylinder walls to increase and by cooling the piston eliminated the trouble with oil cracking. This heat transfer action was further improved upon by the change of lubricating oil, which no longer made a thick coat on the cylinder walls to act as a non-conductor. C. K. LEED.

St. Louis, Mo.

Blowoff Tank with External Water Seal

One morning while an engineer was blowing down a boiler, a cloud of vapor suddenly issued from the pit in which the blowoff tank was located. An investigation showed that the shell of the tank, which stood vertically, had been ripped open from top to bottom.

A new tank was set horizontally in a pit where it could be gotten at readily for inspection. This tank was 36 in. in diameter and 60 in. long. It was made



METHOD OF PROVIDING SEAL OUTSIDE OF TANK

of ⅜-in. steel. As shown in the sketch, the 2-in. blowoff pipe leading from the boiler was connected to the head at a point above the axis of the shell, and the 4-in. outlet piping was arranged so that the lower side of the horizontal nipple at *A* was level with the center of the tank. This insured an empty space into which the discharge from the boiler could enter, since the tank could never be more than one-half full of water. The engineer regarded the external seal formed by the outlet piping as an improvement over the ordinary method of running a pipe inside the tank to form a seal.

St. Louis, Mo. A. J. DIXON.

Curing Commutator Troubles

For a long while we had trouble with fluctuating voltage, growing steadily worse in our plant. Finally, the generator would not build up at all until the exciter brushes were pressed with a stick, and at last even this failed. An automobile storage battery was obtained, and the alternator could be made to pick up by giving the exciter field coils an initial excitation from the battery. Much sparking was seen at the exciter's commutator, which was black and rough, but as the brushes were set exactly on the neutral mark and cleaning the commutator had little effect, this was thought merely a symptom.

The entire machine was then taken apart, loose connections looked for, everything cleaned, and for a while after the machine was assembled it worked better, but the trouble returned. Brush shifting was tried unsuccessfully. As a palliative an abrasive block was applied to the commutator, which cleaned it up beautifully at once, with marked improvement in operation. Our previous experiments with cleaning the commutator had failed, since the mica was high. The abrasive block cut down the mica and improved conditions, and shifting the brushes cured the trouble for a long time.

When trouble later recurred, it was found at one time to be due to brush pigtails burned in two, at another to a brush sticking in the holder, again to a slight ground, and again to a slight shifting of the brush rigging. In every case the fault was easily detected and removed; the abrasive block served a valuable purpose in cleaning up the commutator.

This block was recommended for use while the machine was carrying load. It was tried, but the abrasive and copper dust got into the bearing of the exciter and burned it out one night before the machine could be stopped. The bearing was rebabbitted after a hundred-mile ride in a Ford over bad roads. We fitted a heavy collar of harnessmakers' felt over the shaft at the end of the bearing, and thereafter took care to blow the dust away from the bearing, and experienced no more trouble.

COLIN K. LEE.

Bowling Green, Mo.

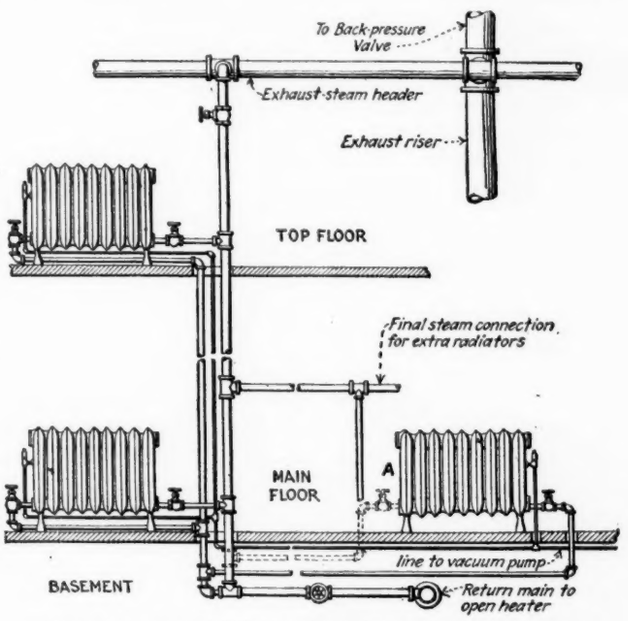
Experience with Steam Heating Installation

At this season of the year the heating system requires more or less attention from the operating engineers, and fortunate is the man who has in his charge a well-designed and properly installed heating plant. In many years' experience as an operating engineer, it has been my privilege to observe the working of quite a number of steam-heating systems, some of which were faulty in construction, while others, after considerable alterations, were put into satisfactory operating condition. In many small and in some medium-sized buildings the first cost of the equipment seems to be of paramount importance.

In considering a new installation or making a change in the old one, the opinion of the man in charge of the plant may not be asked, but a consulting engineer is called in. He measures the spaces to be heated, considers the kind and thickness of the walls, allows for the glass, then calculates the number of square feet of radiation for the present conditions (and none over) and figures the probable cost of the installation. The contractor who makes the lowest bid usually gets the contract, and owing to keen competition some unscrupulous contractors will skimp a job in every way they can, in order to break even on their low bid.

In laying out new installations it is common practice to specify only the smallest size of pipe required for the present radiation, making no allowance for future additional radiation. Take, for instance, a building with large floors, and equipped with sufficient radiation to heat the rooms properly. Then a change in tenants takes place, and offices are partitioned around the walls, by the windows, where the radiators are usually located. As a result these offices become overheated and the valves on the radiators are closed. Then the center of the room is not heated sufficiently, and additional radiators must be installed. It will then be found that the original steam-supply pipe is too small to serve them properly.

I have in mind a new building in New York City in which the layout of the steam-heating system was ideal,



ORIGINAL AND FINAL CONNECTION TO ADDITIONAL RADIATORS

but the installation left much to be desired. During the first winter the plant was in operation, bushels of core sand was taken out of radiators and piping, involving much delay and unnecessary labor. Also, by the careless distribution of pipe hangers in the basement, air pockets were formed in the return lines, which interfered with the return of the condensation. By readjusting the hangers to give the proper pitch to the piping, that trouble was overcome.

The layout of this equipment is shown in the illustration. Steam was taken from the exhaust header on the top floor, with riser serving each floor down to the first. Later, it was found necessary to install additional radiators on this floor as at *A*. A consulting engineer was called in, and he directed that steam should be taken from the riser at a point below the floor (as shown by the dotted pipe line). As the return and exhaust risers were connected together near that point, no steam would flow to the new radiators. Finally, the steam riser was tapped at a point above the radiator as shown, and sufficient steam was then obtained.

M. M. BROWN.

Camden, Me.

Comments from Readers

"Points" of Efficiency

In the Jan. 30 issue of *Power*, under "Easy Lessons in Engineering" there appeared an interesting discussion regarding the proper method of expressing changes in efficiency.

If the efficiency of a piece of apparatus changes from, say, 70 to 75 per cent, there is likely to be some confusion if a mere statement is made that the original efficiency was 70 per cent and that it has been increased 5 per cent, it being indefinite as to whether the increase in efficiency was 5 per cent of the 70 or a "flat" change in efficiency of 5 per cent. Several engineers have found it helpful to speak of such a change as "an increase of 5 points on the efficiency scale," each "point" being one per cent.

W. A. CARTER.

Detroit, Mich.

Grain Size in Condenser Tubes

In the Jan. 23 issue of *Power* D. K. Crampton takes exception to the statement, "Attention has been drawn to the necessity of small uniform grain in condenser tubes as being conducive to longer usage," a statement which was made in the article, "A Year of Progress in the Power-Plant Field," which appeared in the Jan. 2 issue under the heading "Condensers." No doubt, the author of the original article is fully able to take care of himself in a discussion of this subject, but this is written to assure him and other readers that there probably is ample ground for his assertion.

In the second paragraph the critic says that it is debatable whether extremely fine grain size adds anything to service and long life of the tube, but in concluding the fourth paragraph, he does not hesitate to close the "debate" by stating that fine grain size is responsible for increased cost, with no return in increased life of tube. This sweeping conclusion will scarcely dispose of the question, because many engineers hold the opposite view.

The critic says that condenser conditions vary so widely that it has been practically impossible to conduct any tests that would prove definitely the theory that tube life is affected by the fineness of the grain. If this is the case, it would be interesting to know how he has been able so definitely to *disprove* it.

If there are many cases, as the critic asserts, in which fine-grained tubes have failed where coarser-grained tubes have lasted in the same condenser, the writer would look for the cause of failure elsewhere than in the grain size of the tubes.

The columns of *Power* and other technical journals have contained various references to this subject during the last ten years, but never yet have I seen the assertion in print, that a coarse-grained tube resists corrosion longer than a fine-grained tube, other conditions being equal.

Of the several distinct advances in condenser-tube quality recently brought about, there is none that has made a wider appeal than a fine uniform grain size. It would seem to be in line with an intelligently conservative attitude to give it an opportunity to demonstrate its possibilities rather than to condemn it prior to adequate trial. Fine-grained tubes have been found here and there for a number of years, but usually mixed with tubes of different grain size in the same condenser and often showing a lack of uniformity of structure in individual tubes. It is only in the last three or four years that there has been offered a tube whose structure could be guaranteed to be uniform and to have a grain size not exceeding an average of 0.02 or 0.03 mm.

Questions like "excessive wear on dies," "increased tendency toward scratching," and "increased difficulty in meeting narrow dimensional tolerances," all are susceptible of argument, but are purely production problems which interest the manufacturer intensely but the user less so.

The cost of the condenser tube itself is so small when compared with the aggregate costs of labor of replacement and loss of use of units due to condenser outages and corrosion troubles passed along to the boiler tubes, that every increment in the life of the condenser tube means considerable economy in operation.

The cheapest tube is not the one that offers the most pounds for a dollar, but the one that gives the longest service for that dollar.

C. A. GLEASON.

New York City.

Hints on Being Chief Engineer

G. A. Bristow, in the Jan. 2 issue, touches an interesting subject in relating some of his experiences as chief engineer.

Undoubtedly, most engineers who have reached the position of chief will agree that a thorough knowledge of things mechanical is not the only essential part of a man's training in order to become successful in that position.

In my opinion there are other qualifications of as much importance as technical training or mechanical skill. With all our modern power-plant appliances and labor-saving machinery, the human element is still the paramount factor in every plant, and one who lacks the ability of handling men, will never make a real success as chief, no matter what other qualifications he may have acquired by college training or practical experience. He may be able to run the plant and even get results as far as economy is concerned, but it will probably be under such trying conditions that the work will be anything but pleasant.

A few of the characteristics that a chief must have to create loyalty among his men and build up a good organization are to be absolutely on the square, not to show favoritism to anyone, to treat each one as a man, from the one who handles the ashes to those higher up, to encourage personal efforts toward better operation and to listen to suggestions and adopt practical ones.

He should also be prepared to handle any emergency and have ability to deal with problems as they come up. Any man of reasonable ability should pick up sufficient practical knowledge of machinery in general in ten or twelve years of power-house work to run any ordinary plant even if he is not what may be called technically trained. Life is rather short to specialize in every branch of the engineering subjects that go to make up a power plant and one should endeavor to obtain assistants who have perhaps more experience in their special lines of power-plant work than one chief could acquire in a lifetime.

Of course a good technical training is a great asset to any chief, but many of the chiefs in charge of the largest power plants throughout the country are not technical college graduates.

To take charge of a new plant just being installed, where one has ample opportunity to get familiar with all the equipment long before the time comes to put the plant into operation and where a man can pick his own crew is quite a different problem from taking charge of a plant where your predecessor has possibly been discharged on short notice and where perhaps the majority of the old crew is prejudiced in favor of the old chief and not anxious to give any information as to details and peculiarities of the plant. This is where a cool head and a knowledge of human nature count as much as operating experience. Many a man has declined to step into a bigger job under such conditions because he lacked the nerve to tackle it.

The trouble with some engineers when they take charge of their first plant in the capacity of chief, is that they are too much concerned with their own importance. It has been my experience that the more a man tries to impress you with his own importance, the less successful he is as an executive.

Youngstown, Ohio. R. CEDERBLOM.

Should Steam for Heating and Process Be Charged to Power-Plant Costs?

I was much interested in the article in the Jan. 16 issue by John Maconnell, entitled, "Should Steam for Heating and Process be Charged to Power-Plant Costs?" His statement of the method of cost keeping in the plant with which he is connected indicates a condition that exists, to a great extent, in the majority of industrial plants, and this false method of book-keeping leads the management of many factories to believe that power generated in their own plants is more expensive than central power.

In localities where heat is an absolute necessity for six or seven months of the year or where steam is required in manufacturing, there is but one correct way of distributing the charges between heat and power. As the steam must be generated for heat, the fixed charges on all boiler and auxiliary equipment required to generate this steam, together with coal, labor and supply costs should be charged directly against heat. If by means of a steam-driven generating unit sufficient energy can be extracted from the steam before going to heating or process work to furnish the power and light required, all that should be charged against power is the fixed charges on the generating unit and auxiliary equipment together with supplies and repairs. If, on the other hand, the power requires more steam than is used in heating or process, it should be charged with the additional coal and water used by the unit, together with the fixed charges on any additional boiler equipment that may be required to take care of the power load. As a rule, where a plant is sufficiently large to require a generator of 200-kw. capacity, a licensed engineer is in charge whether a power plant is installed or not, and consequently there is seldom any extra labor to be charged against the power.

When costs are distributed in this way, it will be seen that most industrial plants of fair size cannot afford to buy power and burn coal for heating or process work at the same time, as the amount actually charged against power is so small as to reduce the cost per kilowatt-hour to a figure below the selling price of current. I have no doubt that if this method of distributing costs were used in Mr. Maconnell's plant, the cost of current would be almost cut in two. S. S. WILSON.

Chicago, Ill.

Evaporation of Lubricating Oil

The question, "Will a lubricating oil evaporate from becoming heated?" asked by R. C. M. in the Jan. 16 issue, brings to mind some experiences with the excessive evaporation of oil in engines of the splash-oiling type, where the oil is used over and over again with no provision for cooling before returning it to the bearings. To one who has never run an engine of this type, the amount of oil lost through evaporation may seem almost incredible. One is forced to the conclusion that the oil is evaporated, for the small amount of leakage will not account for the loss.

In a plant consisting of a 500-kw. steam turbine and its auxiliaries, three medium-speed engines, one 12x12-in. high-speed engine, a small high-speed air compressor, and 55 induction motors aggregating 1,100 hp., the 12x12-in. engine, which was of the splash-oiling type, used more oil than all the rest of the plant combined. Different high-grade oils were tried, but always with the same result—it quickly disappeared.

In another plant a 13x13-in. high-speed engine with a splash-oiling system, running 24 hours a day, required nearly a gallon of high-grade oil a day to make up for the loss from evaporation. There was not enough water got into the oil to cause deterioration, though the drips from the stuffing boxes were piped into the crankcase.

Another cause for excessive evaporation of oil in engines of the splash-oiled type, besides high oil temperature, is the large amount of oil surface exposed to the air as it is thrown to the inclosed parts of the engine. It is somewhat comparable to the cooling of condensing water with spray nozzles, in which the evaporation of a part of the water, to which the cooling effect is principally due, is accentuated by breaking up the water into a fine spray and thus exposing a greater surface of it to contact with the air. H. G. ROBERTS.

Seattle, Wash.

A water-cooled, oil-insulated transformer should not be operated with the cooling water shut off; even without load the losses in the iron and winding are sufficient to cause the temperature to rise above the danger point. Deposits formed in the cooling coils, through which the circulating water flows, act as a heat insulator and also tend to reduce the amount of water passing through the coils. Generally, such deposits can be removed by passing a solution of muriatic acid and water through the coils.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Purposes of Lead

Why is lead considered an advantage in the operation of an engine? M. P. C.

The advantages of admitting steam before the piston arrives at the end of the stroke are to assist in bringing the reciprocating parts to rest, raising the pressure in the clearance space to full value before the piston starts on its stroke, and in obtaining a wider opening of port through which the steam can be admitted and thus reduce wiredrawing with drop of pressure during the early part of the stroke.

Relative Boiler Efficiency at Different Pressures

Will a water-tube boiler in generation of large quantities of steam operate as efficiently at 90 lb. as at 150 lb. gage? A. B. M.

With the same temperature of feed water, the equivalent evaporation from and at 212 deg. F. should be slightly greater for generation of steam at the lower pressure, as with a lower temperature of steam and water of the boiler, there may be absorption of more heat by the boiler accompanied by lower temperature and less waste of heat in the chimney gases. But the greater efficiency when generating steam at the lower pressure would be so small as to be inappreciable.

Heat Absorbed by Jet Condenser

How can it be known how much heat is absorbed by the cooling water supplied to a jet condenser? J. W. E.

If it is known what quantity of cooling water is supplied per hour, then the number of B.t.u. absorbed will be the number of pounds of cooling water multiplied by the number of degrees F. difference between the temperature of the water as received and as discharged.

Knowing the number of pounds of steam condensed per hour, the quantity of cooling water is obtained with close approximation by the formula,

$$W = \frac{H - t_2 + 32}{t_2 - t_o}$$

in which

W = Weight of cooling water in pounds necessary to condense and cool one pound of steam to the discharge temperature;

H = Heat content of the steam at condenser pressure;

t_2 = Temperature of the discharge water,

t_o = Initial temperature of the cooling water.

It is sufficiently accurate for most practical purposes to assume the exhaust steam entering the condenser to be dry and saturated and its heat to correspond to the pressure in the condenser, as given in steam tables.

Releasing vs. Positive Corliss Valves

What are the relative advantages of releasing and positively operated Corliss valves? A. S. M.

With a releasing valve gear the cutoff occurs rapidly, regardless of the speed or load; operation of the engine is limited to the speed at which the valve gear will operate in opening and releasing the valves; and the valve gear is noisy as compared with positively operated Corliss valve mechanism. Positively controlled Corliss valves may be operated at higher speeds; operation of the valves is practically noiseless and shaft governors are more applicable to valves operated in that manner than when operated by detaching valve gears. But for long stroke, slow-speed engines positively operated, valves do not give as quick cutoff as releasing valve gears.

Failure of Firedoor Arches

What causes frequent failure of built-up firedoor arches of a return-tubular boiler? The trouble seems to occur most frequently during seasons when we use a forced-draft blower. E. R. K.

Built-up firedoor arches unless carefully constructed may become loosened at the joints from being disturbed by back and forth movement of the boiler from expansion and contraction, but most frequently the firebrick of these arches become loosened from their own expansion, owing to the high temperatures when the doors are closed and contraction from cooling when the doors are opened. With a forced draft there may be greater pressure above the fire than necessary to balance the pressure of the atmosphere. In such cases the heated gases are forced through the joints and crevices of the firedoors and arches, and alternations of extensive expansion and contraction of the material soon result in failure of the arches unless they are of monolithic construction.

Methods of Superheating Steam

What methods are employed in boiler plants for superheating steam? R. L. H.

There are three methods in use for superheating steam. The first, and probably the most economical method, is to pass the saturated steam through coils of pipe placed in the path of the hot flue gases on their way from the boiler to the chimney. Unless the saturated steam has a very high pressure, at least 100 deg. of superheating may be obtained by this method from heat that would otherwise be wasted in passing out of the chimney in the flue gases. Another method consists in placing the superheater inside of the boiler setting, allowing the hot gases to pass through the superheater before leaving the boiler, or before they are brought

into contact with the boiler-heating surfaces. The commonest arrangement is to place the superheater in the last pass of the heated gases before they leave the boiler. High temperatures are thus available; but the tendency of later designers is to place the superheating surfaces in the earlier passes as the degree of superheating may be controlled more uniformly.

A third method of superheating is to have the superheater independent of the boiler and separately fired. With this method the temperature may be closely regulated, but the method is more wasteful of fuel than either of the other methods.

B.t.u. and Maximum Percentage of CO_2 from Combustion of Natural Gas

What is the heat value per cubic foot and maximum CO_2, from perfect combustion of a natural gas of the following composition: CH_4, 84.7 per cent; C_2H_6, 14.3 per cent; O_2, 0.5 per cent; CO_2, 0.5 per cent?

A. C. M.

The heat value per cubic foot at 32 deg. F. and atmospheric pressure for CH_4 = 1,012 B.t.u., and the heat contributed by the CH_4 = 84.7 per cent of 1,012 B.t.u. = 857.2 B.t.u. For C_2H_6 the heat value per cubic foot = 1,772 B.t.u., hence the heat contributed by the C_2H_6 = 14.3 per cent of 1,772 = 253.4. Hence the heat value per cubic foot of the gas = 1,110.6 B.t.u.

In combustion of CH_4 (methane),

$$CH_4 + 2O_2 = CO_2 + 2H_2O \ (water);$$
$$1\ vol. + 2\ vol. = 1\ vol. + 2\ vol.\ (to\ water).$$

In combustion of C_2H_6 (ethane),

$$2C_2H_6 + 7O_2 = 4CO_2 + 6H_2O \ (water);$$
$$2\ vol. + 7\ vol. = 4\ vol. + 6\ vol.\ (to\ water).$$

In CO_2 analysis of flue gas the H_2O condensed to water is not taken into account, as it is a negligible volume.

When 100 cu.ft. of the gas is burned with the theoretical oxygen, the results are as follows:

Gas	Vol. O_2 Used per Cu.Ft.	Vol. CO_2 Produced per Cu.Ft.	Actual Cu.Ft. of Gas	Actual Vols. O_2	Actual Vols. CO_2
CH_4	2	1	84.7	169.4	84.7
C_2H_6	7/2	2	14.3	50.05	28.6
O_2	−1	0	0.5	−0.5	0.0
CO_2	0	1	0.5	0	0.5
Total				218.9	113.8

Volume of nitrogen taken in to burn 100 ft. of the gas $= \frac{79}{21} \times 218.9 = 823.5$ cu.ft.

Using whole numbers, the total air required per 100 cu.ft. gas = 824 + 219 = 1,043 cu.ft. and the final mixture is:

$$N_2 = 824\ cu.ft.$$
$$CO_2 = \frac{114\ cu.ft.}{938\ cu.ft.}$$

$$Maximum\ per\ cent\ CO_2 = 100 \times \frac{114}{938} = 12.1\ per\ cent.$$

Effect of Loop in Steam Connection of Water Column

If there is a loop in the steam connection of a water column, will a glass gage connected to the water column show the boiler-water level as correctly as if there were no loop in the connection? J. K.

On account of the condensation of steam that takes place in the steam connection of a water column there is a reduction of pressure; but if the connection does not form a trap, the boiler pressure is so nearly maintained in the upper part of the water column that the glass gage may be considered to indicate the level of water in the boiler as correctly with a loop as without a loop.

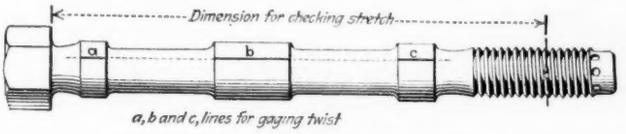
If the connection is a loop that forms a trap in the steam connection, the steam pressure in the top of the water column becomes reduced from condensation of the steam immediately after the trap becomes sealed with condensate. Then the greater pressure in the steam connection forces the trapped water to a higher level in the side of the loop that is connected with the water column and, with the continuation of the reduction of pressure in the top of the water column, the water level in the glass gage rises above the water in the boiler. The water thus may become backed up so much as to flood the glass gage and the water column completely. Hence, with a looped or other connection that forms a trap, the boiler-water level can not be correctly indicated by the glass gage.

Checking Stretch and Twist of Connecting-Rod Bolt

How may the stretch of a connecting-rod bolt of a Diesel engine be detected? Also, is it possible to determine if the bolt has been twisted by sledging up?

W. N. H.

Each time the connecting-rod bolt is sledged up, it is stretched a slight amount. This does no harm unless the sledging has been severe enough to give the bolt a



CHECKING STRETCH AND TWIST OF CONNECTING-ROD BOLT

permanent "set." To detect this, file a flat spot on a screw thread and make a prick-punch mark, as shown in the illustration. Measure the distance between this mark and the under side of the bolt head. Better still, make a gage. When the bolt is removed, remeasure this distance and if it proves longer, the bolt has been permanently stretched and a new one should be procured.

To detect twisting, scratch a line along the bearings of the bolt as shown at *a*, *b*, *c*. By placing a straightedge along these lines, any permanent twist is at once detected.

Bursting of Water Pipes from Freezing

When water pipes are burst by freezing, at what temperature does the rupture occur? W. B. L.

Rupture usually occurs while the water is passing to the solid state or when the temperature is raised back to the freezing point which for quiet water at atmospheric pressure is 32 deg. F. and for higher pressures is about 0.0135 deg. F. higher for each additional atmosphere of pressure.

During the freezing process the volume becomes about 8½ per cent greater than water at 32 deg. F., or the volume may increase a slightly less amount when the original water has been freed from air by boiling. After ice has formed, a further reduction of temperature is accompanied by contraction of the volume and re-heating to the freezing temperature causes expansion back to the initial ice volume at 32 deg. F. and rupture of a pipe from freezing may occur when that temperature causes the initial freezing or when 32 deg. F. is restored just before thawing takes place.

Easy Lessons in Engineering

Figuring Areas of Flat Surfaces

The area of a rectangle is the product of the base by the height. This is easily seen by cutting it into unit squares. In *A* (Fig. 1), for example, there are 5 rows of one-inch squares, 7 in a row, or $5 \times 7 = 35$ in all, so the area must be 35 square inches.

The same rule applies for a parallelogram, which is a four-sided figure where the opposite sides are equal and parallel. For example, *B* has an area of $5 \times 7 = 35$ sq.in., the same as *A*. This is made evident by drawing (in dotted lines) the 5x7-in. rectangle. Then it is seen that the parallelogram falls short of filling the rectangle by the area of the triangle at the left and runs over by the area of the equal triangle at the right. The deficit at the left equals the excess at the right, so the area of the parallelogram is equal to that of the rectangle.

The area of a triangle is equal to half the base times

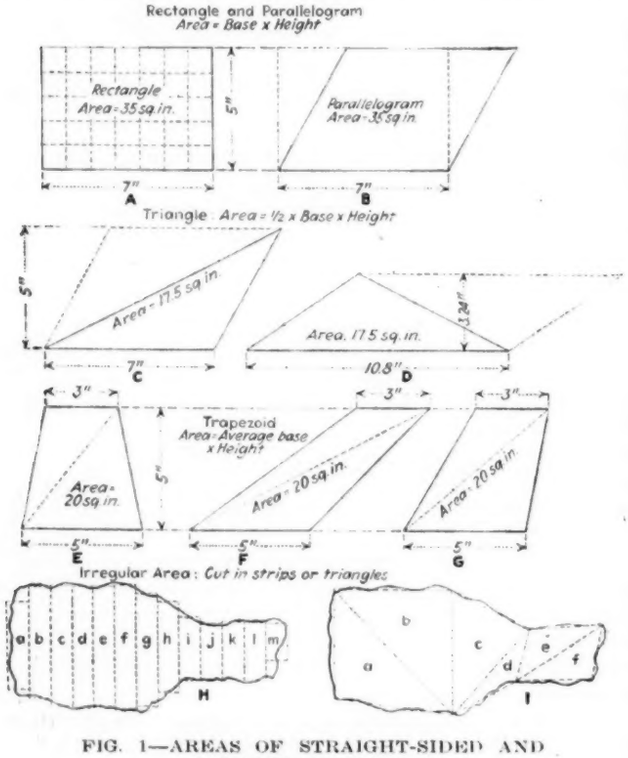


FIG. 1—AREAS OF STRAIGHT-SIDED AND IRREGULAR FIGURES

the height. This is seen by completing the parallelogram, as at *C* where the area of the triangle is seen to be half that of the parallelogram, or $\frac{1}{2} \times 5 \times 7 = 17.5$ sq.in. The same answer is obtained if the triangle is turned over, as at *D*.

A trapezoid (as illustrated by *E*, *F* and *G*) has two parallel sides called the bases. *The area of a trapezoid is the product of the height by the average of the two bases.* To understand this, split the trapezoid into two triangles as shown. Then the area of one triangle is the height times half the upper base, and the area of the other is the height times half the lower base. So the total area must be the height times the sum of half

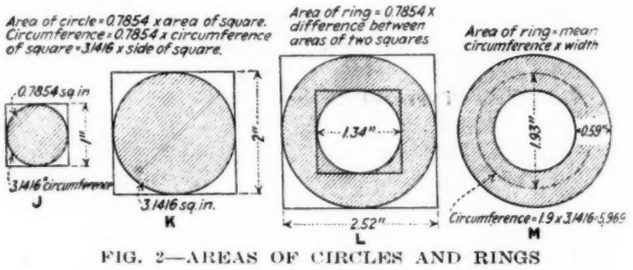


FIG. 2—AREAS OF CIRCLES AND RINGS

the upper base and half the lower base, or the height times the average of the two bases.

An irregular area, or one for which no rule is handy, may always be figured by cutting it up into rectangles or triangles as shown at *H* and *I*. When using the method shown at *H*, it is most convenient to make all the rectangles of the same width, so that the area can be figured as that of the single long strip obtained by placing the small strips end on end.

Fig. 2 illustrates the methods of figuring circles and rings. Imagine a square drawn around a circle as at *J* or *K*. Then *the area of the circle is 0.7854 times the area of the square, and the circumference of the circle is 0.7854 times the circumference of the square.* In *J* the area of the square is 1 sq.in. and its circumference 4 in., so the area of the 1-in. circle is $0.7854 \times 1 = 0.7854$ sq.in., and its circumference $0.7854 \times 4 = 3.1416$ in. From the last result we can get another rule, namely, that *the circumference is equal to 3.1416 times the diameter.* In the same way the area of the 2-in. circle in *K* is $4 \times 0.7854 = 3.1416$, and its circumference is $2 \times 3.1416 = 6.2832$.

The area of a ring is the difference between the area of the inner and outer circles. Since the reader already knows how to figure the area of the two circles, this rule is sufficient, but the two short cuts illustrated by *L* and *M* may sometimes prove convenient. In *L* squares are imagined as drawn around the inner and outer circles. Then *the area of the ring is equal to 0.7854 times the area of the "square ring"* formed by the space between the two squares. The area of the outer square is $2.52 \times 2.52 = 6.3504$, and that of the inner square $= 1.34 \times 1.34 = 1.7956$, so that the area of the square ring is $6.3504 - 1.7956 = 4.5548$, say 4.555. Then the area of the ring equals $4.555 \times 0.7854 = 3.58$ square inches.

The method shown at *M* is probably the best to use in most cases. The ring there shown has the same dimensions as that shown at *L*. *The area of the ring is equal to its width times its average circumference.*

Spray Cooling Equipment for Ice Plants*

Spray nozzles have been used for the recooling of condenser water in connection with steam plants for a number of years. The first nozzles were designed for high pressure, resulting in prohibitive operating costs. This design, however, was superseded by the low-pressure nozzle requiring only 4 to 8 lb. for sufficient atomization of the water. When first applying this method of cooling water to the ice plant, the arrangement, spacing and supply headers and size of nozzle to be employed were features not given consideration, so that the result was unsatisfactory cooling. All these points have been fully studied and tested out, and spray systems are now giving excellent satisfaction for this application.

Since air is the cooling medium, it is evident that to obtain a maximum cooling effect the finely divided water particles must have intimate contact with the air. There are two types of spray—the full-mass and hollow conical spray. The hollow conical spray may be best illustrated by the lawn-spray type. No water is discharged in the center of the spray.

Two Types—Rigid and Adjustable

Spray nozzles may be classified in two groups—the rigid type and the adjustable type. The former is subdivided in two designs, one type having a stationary core, this core consisting of a series of vanes giving the water a centrifugal motion and producing minute drops, or spray, as the water passes through a restricted orifice. The type of spray discharged will be determined by the design of the core.

The rigid-type nozzle has no core, and the spray is produced by the water entering a mixing chamber through a tangential port. This design has been used successfully for a number of years in small nozzles for air conditioning where the spraying capacity is from 1 to 6 gal. per min. Recently, this same design has been employed on water-cooling systems where the nozzle capacity may be as great as 150 gal. per min. The spray is discharged in a hollow conical shape, the included spray angle being approximately 60 deg. The water is discharged approximately 10 ft. above the tip of the nozzle.

Adjustable spray nozzles are so designed that the quantity of water discharged may be varied by increasing or decreasing the aperture, which is accomplished by a series of levers operated at a distance from the nozzle. This spray covers considerable area and is of the hollow conical type.

Nozzles may be arranged in cluster groups of three, four or five. The five-nozzle arrangement is generally used. Four nozzles are placed so as to spray vertically at a distance of 5 ft. from the center, the fifth nozzle being located in the center of the group. This arrangement gives a slight air movement, which is of advantage under certain atmospheric conditions. The spacing of such groups is usually on 13-ft. centers. Parallel supply headers should be at least 20 ft. apart, depending upon the spraying capacity of the clusters, and if a 20-ft. margin to the edge of the spray basin on all four sides is allowed, the windage loss will be slight. Inasmuch as the majority of spray installations for ice plants are located on the roof of a building, the space available determines the arrangement. The surrounding conditions will also determine if louvers will be required. A 10-ft. louver is usually of sufficient height, assuming the nozzles are placed 3 ft. above the roof surface.

There are two types of louvers—the horizontal and the vertical. The horizontal type is usually made up in 6-ft. sections, the louver or deflector being placed on an angle of 45 deg. and spaced on 4-in. centers. The posts may be bolted to the coping, although the better arrangement is to set them back 3 to 6 ft. from the coping. For air circulation there should be a space of 18 to 24 in. left open between the roof and the first deflector board.

If it is necessary to build a louver close to the coping, it is possible to arrange a splash board which will extend 18 in. off the outside of the louver to catch the water. Better cooling effect is obtained with the horizontal louver owing to the fact that the deflector boards are set at an angle so that the air is deflected downward, causing considerable air movement under the nozzle clusters.

The vertical louver is usually made up in 10-ft. units and of a tee section. Under high wind velocities no water will pass through, but this louver has the disadvantage that the air entering the spray basin is not deflected under the sprayed water.

When spray systems are employed to re-cool water from steam condensers for power units, 1 or 2 deg. do not have a great effect upon the vacuum, but this small difference in the temperature of the cooling water from ammonia condensers has a decided effect. In practice the aim is to keep the temperature range within certain limits, say 4 to 12 deg., depending upon the quantity of water circulated.

The size of the spray system is usually based on spraying 4 gal. of water per minute per ton of refrigeration. This results in a temperature range of approximately 7 deg., and under such conditions a properly designed spray system will cool the water within 3 deg. of the wet-bulb temperature, the operating pressure being 7 lb.

From careful test taken during the last four years, it would appear that the five-nozzle cluster arrangement using 1¼-in. nozzles and having a spraying capacity of 100 gal. per min., gives the maximum cooling effect. The initial cost of such an installation, consisting of nozzles, clusters, necessary wrought-steel piping and fittings over spray deck will vary between 45 and 55c. per gal. per min. The cost of horizontal cypress louvers 10 ft. high made up in 6-ft. sections will be approximately $22 per section. The vertical-type louver of equal proportions will be 15 per cent cheaper. These costs do not include erection.

Since the pressure required to obtain satisfactory results from a spray system is only 7 lb., the pumping costs are reasonable. The maintenance cost cannot be great since the equipment is operated under low pressure. The materials used are capable of resisting corrosion. The evaporation loss will vary from 1½ to 2½ per cent, depending on the climatic conditions and water temperatures. The windage loss may be reduced to a small percentage if properly designed louvers are installed.

*Abstract of paper read before Chicago Section of American Society of Refrigerating Engineers, Jan. 30, 1923, by B. R. Sausen of the Binks Spray Equipment Company, Chicago, Ill.

Providence Engineering Society's Annual Banquet

With an attendance of over six hundred the seventh annual banquet of the Providence Engineering Society, at the Providence-Biltmore on Feb. 7, proved the most successful in the history of the organization. Affiliated and co-operating with it were the local sections of the American Association of Textile Chemists and Colorists, American Chemical Society, American Institute of Electrical Engineers, American Society of Civil Engineers, American Society of Mechanical Engineers, American Society for Steel Treating and the Technology Club of Rhode Island.

Dr. S. W. Stratton, president of the Massachusetts Institute of Technology, and Honorable James Hartness, ex-Governor of Vermont, were the principal speakers. Other speakers were Governor Flynn of Rhode Island, who welcomed the engineers on the behalf of the state, and Mayor Gainer of Providence, who extended the greetings of the city and reviewed how the engineer had assisted in solving many of the city's problems and would be called upon to help solve those in the future.

R. H. Newcomb followed and spoke on "The Engineer as a Man," pointing out that there is great need for real, live, capable men who can lead in public work. Referring to transportation, he likened the railroad to a manufacturing plant and said, "You cannot have a strong transportation machine unless there is a safe margin between production costs and income."

Dr. Stratton emphasized the value of research as an adjunct to engineering and pointed out that, after all, the

engineer and the scientist are not very far apart. He mentioned some of the work of the Bureau of Standards, of which he was formerly director, and told how at a cost of from $75,000 to $100,000 the bureau had standardized constants for ammonia tables which had been of invaluable aid to the refrigerating industry.

During the war the work of the bureau in the testing of airplane engines under reduced pressure in a compartment analogous to operation at high altitudes, had made possible the development of a successful airplane engine. In other cases standardization of products had enabled the manufacturer to reduce his production cost to pre-war figures. "One of the present problems of the engineer," said Dr. Stratton, "is the solving of our distribution system, the costs of which are now excessive. One of the functions of the educational institution is to provide men capable of research."

Mr. Hartness declared that the world had never faced such conditions as now. He told of the work of the different branches of engineering science and their parts in the development of the country and its industry, and said that now the entire fabric was being tested. While the vital parts of the machine are all right, the whole machine stops when the few become dissatisfied. He said:

"We must now give thought to the protection of the country and the home. We must bend every effort to correct such things as tend to deprive all of an equal opportunity. Laws cannot keep pace with the advancement of machinery. There are things about the Government that are not right, but business must not be interrupted. To interrupt transportation will starve the people in the towns and work havoc with the men on the farms. We must make it clear that interruption of transportation is bad and will reduce the wages of both labor and capital.

"Engineers must see that nothing interrupts the progress of government. We must go back to the war-time requirement that everyone must perform essential service. All must realize that the country cannot be protected by the Army and Navy. While we need them, we also need to protect the old ship from troubles within. Go into political life. Remember that you can serve in your profession, in your life, by preaching stability of government."

A.S.M.E. Discusses High-Temperature Alloys

Just now there is a widespread and rapidly growing interest among mechanical engineers in the subject of high-temperature alloys. This matter has been forced upon their attention by the development of internal combustion engines, electric heating and measuring devices and the recent tendency to go to the higher steam pressures and temperatures. All of these phases of the subject were touched upon by Prof. Hunter, of Rensselaer Polytechnic Institute, in a lecture recently delivered at Newark, N. J., before the Metropolitan Section of the A.S.M.E. The following short abstract of his talk is devoted mainly to those portions that are of primary interest to power-plant engineers.

The line between high-temperature and low-temperature alloys is usually drawn around 1,800 deg. F. Any alloy that melts above this temperature may be considered a high-temperature alloy. There are only a few elements that may be commercially combined to give melting points in this high range. Such rare metals as titanium and platinum, which have melting points around 3,200 deg. F., cannot be considered commercially on account of their cost. Some of the more common metals may be arranged as follows, in order of their melting points: Iron 2,770 deg. F.; chromium 2,760 deg. F.; nickel 2,590 deg. F; and aluminum 1,260 deg. F. Metals whose melting point is below 1,800 deg. F are rarely found as constituents of high-temperature alloys.

In general, high-temperature alloys consist of two or three components, united in what the metallurgists call a "solid solution." Most of the low-temperature alloys, on the other hand, form what are called "eutectic" mixtures. The solid solutions differ in many ways from the eutectic mixtures. With eutectic mixtures, for example, the electrical resistance, starting with 100 per cent of one constituent, varies along a straight line as the mixture gradually changes to 100 per cent of the other constituent. This rule holds for lead-tin alloys. The solid-solution alloys, on the other hand, do not give a straight-line relation between composition and resistance, so that an alloy of this sort may have a much higher electrical resistance than either of its constituents. Practically all of the high-temperature alloys to be described come under the heading of solid solutions.

The copper-nickel mixtures form a valuable class of alloys. For example, Monel metal, a natural alloy consisting of about 30 per cent copper and 70 per cent nickel, can be carried up to about 1,200 deg. F. before it begins to oxidize. The melting point of Monel metal is 2,480 deg. F. It has a high electrical resistance. On account of its resistance to moderately high temperatures and the fact that it has good physical characteristics of strength, elongation, etc., and can be worked, it has found wide application for such uses as valve seat and disks.

Some of the most valuable of high-temperature alloys are found in the combinations of nickel and chromium. These should not be confused with nickel-chromium-iron alloys. The melting points of nickel and chromium have already been given. The melting points of the alloys are usually somewhat lower. For example, an alloy with 42 per cent of nickel melts around 2,350 deg. F. This, however, is a hard alloy to work. Sometimes as much as 90 per cent of nickel is used, this giving a melting point of 2,640 deg. F.

Probably the most generally useful combination is 80 per cent nickel and 20 of chromium, with a melting point of 2,600 deg. F. The great importance of this alloy is due chiefly to its ability to stand oxidation at high temperatures. Alloys with practically any proportion of chromium can be formed by casting, but for other methods of working the chromium should not exceed 20 per cent. It is understood that the patent for nickel-chromium wire has just expired.

Of alloys containing nickel, chromium and iron, probably the most useful is "nichrome." This contains 26 per cent of iron and 12 per cent chromium, the balance being nickel, with traces of impurities from the electric furnace. The melting point of this alloy is about 2,480 deg. F. Its outstanding characteristic is high tensile strength at very high temperatures, as indicated by the following table:

Temperature, Deg. F.	Tensile Strength, Lb. per Sq.In.
Room temp.	67,000
1,110	44,000
1,560	20,000
1,830	12,000

While showing good ductility at high temperature, this material is not particularly ductile at ordinary temperatures. It has proved useful for the manufacture of valves for automobiles and Diesel engines and can also be used in a great majority of the cases where resistance wire for electrical heating coils is required.

Still another class of alloy is the iron-chromium group, of which the stainless steels are the most important examples. These have been put on the market with as much as 15 per cent of chromium. However, there seems to be no reason why higher percentages of chromium up to 35 per cent should not form useful alloys.

A number of interesting points were brought out in the discussion. The question was raised as to whether nickel-chromium-iron alloys would be suitable for use in boilers and superheaters operating at extremely high pressures and superheats. Prof. Hunter felt that at the temperatures encountered the material would probably not be injured appreciably by the sulphur content of the gases. One of the manufacturers present spoke of inquiries he had received for materials to stand temperatures up to 1,200 deg. F., in tubes under pressure. He said that one of the great fields for development along this line would be found in connection with oil cracking.

In closing the meeting, S. H. Libby, who served as chairman, commented on the remarkable advances that had been made in metallurgy and on those that were just ahead.

News in the Field of Power

Power Load During 1922

Record-Breaking Production of Electricity Reflects Industrial Recovery and Growth

BREAKING all records for the sixth time since last May, the average daily production of electricity by public-utility power plants in December was 146,700,000 kw.-hr., according to the latest report of the Geological Survey. This record consumption of power for the last six months is a clear indication of the recovery and growth of the nation's industries since the depression of two years ago.

The accompanying curves show that the increase in power production since May, 1922, has been confined entirely to steam plants, the water-power curve falling off from its peak in May because of the seasonal decrease in the quantity of water available. The proportion of the total output produced by water power during 1922 reached a maximum of 43.1 per cent in May, falling to 30.4 per cent by the end of the year.

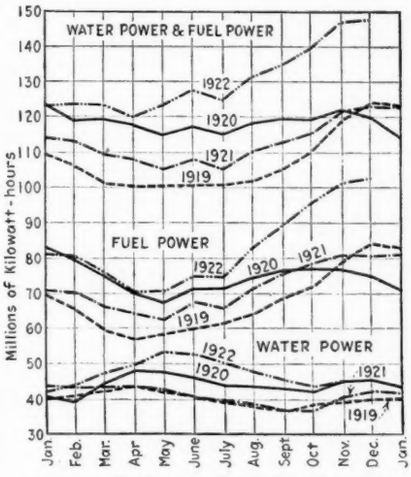
The Survey's report is based on returns from about 3,500 central stations and other public-service power plants, each producing 10,000 kw.-hr. or more per month. Although in each report the figures for the last month, and sometimes for the last two months, are revised owing to the receipt of data after publication, as a rule this revision is small.

Over 1,000,000 Kw. in Large Turbines on Order

The increasing demand for power is reflected in the fact that over a million kilowatts in large turbo generators have been placed on order with the General Electric Co. and the Westinghouse Electric & Manufacturing Co. within the last few months. In a number of cases, public utilities and large industrial plants have been unable to await the completion of projected plants, being forced to enlarge their existing stations immediately.

The Detroit Edison Co. has contracted for three 50,000-kw. G. E. turbines for installation in a new station at Trenton Channel. The American Gas & Electric Co., New York City, controlling the Ohio Power Co., has ordered four 35,000-kw. Curtis turbines for the new station at Philo, Ohio, to supplement its Windsor (West Va.) station in serving the Ohio territory. Orders for 30,000-kw. G. E. turbines have been placed by the Cleveland Electric Illuminating Co., the Public Service Co. of Northern Illinois, the Minneapolis General Electric Co. and the Commonwealth Edison Co. of Chicago. The Philadelphia Electric Co. has ordered two units of this size. The New York Edison Co. has ordered a 35,000-kw. G. E. turbine and a frequency changer of the same capacity.

The Westinghouse company has received orders for turbo generators aggregating nearly 600,000-kw. from utilities prominent among which are the Brooklyn Edison Co. (Hudson Street station), 62,500 kw.; Commonwealth Edison Co. (Crawford Ave. and Calumet stations), 87,000 kw.; West Penn Power Co. (Springdale plant), two 30,000-kw. units; Connecticut Light & Power Co., three 25,000-kw. units;



NEW PEAKS IN POWER CURVES

The 1922 curves of average daily production of electricity by public utilities established records for both fuel and water power.

Middle West Utilities Co., two 25,000-kw. units; Indiana Public Service Co., two 25,000-kw. units; Public Service Production Co. (New Jersey), 25,000 kw., and Toledo Edison Co., 37,500 kw.

New Municipal Plant for Manchester, England

The new steam-power station now being built about eight miles outside of Manchester, the center of England's largest industrial area, will eventually be one of that country's most important stations and will represent the last word in modern British practice.

Built and operated by the municipality, the new power plant will occupy an ideal site, with a ship canal alongside providing both water transportation of coal and a supply of condensing water. Arrangements are being made to supplement the water supply, if necessary, by effluent from the Manchester sewage works.

The buildings are being laid out for a total ultimate capacity of 150,000 kw. The turbine house is 243 ft. long, 65 ft. wide and 46 ft. high at the maximum. Steam at 350 lb., superheated to 700 deg. F., will be supplied by nine double-fired Babcock marine-type boilers, each having a normal rating of 100,000 lb. steam per hour. Each boiler, with its stoker, economizer, superheater, air heater, stack and fans, will be a complete unit in itself.

The initial installation will consist of three 27,500-kw. turbo-generators, made by the Metropolitan Vickers Co.

No Coal Legislation Yet

Congress Puts Off Bills to Increase Powers and Funds of Coal Commission—No Successor for Alschuler

PROCRASTINATION and lack of interest on the part of Congress is handicapping the Coal Commission in its work and lessening its possibilities for usefulness. Early in its term, the commission asked for legislation to make compulsory the returns submitted on questionnaires, with penalties for failure to reply. As this is written, there still is much uncertainty as to when that legislation will be forthcoming. It remains to be seen, also, whether or not the same dilatory policy will prevail in the handling of legislation carrying $400,000 for the commission's expenses.

The attitude of the legislative bodies toward the Coal Commission cannot be attributed to any displeasure with the work the commission has done. On the contrary, opinion on Capitol Hill is very generally favorable to the commission. The personnel of the commission is universally admitted to be strong. The failure to uphold the hands of the commission is simply another indication of the lack of consistency in carrying forward legislative policies. At the White House it was announced that Judge Alschuler had resigned from the Coal Commission chiefly because under the existing law he could not serve on the commission and at the same time hold his position on the Federal bench. Had Congress enacted the legislation originally proposed to enable him to qualify, it is believed that Judge Alschuler would have been glad to continue on the commission. The vacancy caused by his resignation probably will not be filled, it was announced at the White House on Feb. 13.

John W. Sargent Dies

John W. Sargent, expert engine designer and founder of the Providence Engineering Works, died in Providence, R. I., on Jan. 29 after a brief illness.

Mr. Sargent was born in Amesbury, Mass., in 1856, and, after a public school education, entered the Amesbury Machine Works, where he learned the machinist's trade. Later he entered the class of '78 in the Massachusetts Insti-

tute of Technology, graduating with honors. He took a position with the William Cramp's Ship Building Works at Philadelphia, and later was employed at the Dixon Manufacturing Co., Scranton, Pa., where he eventually became chief engineer and designer.

In 1895 Mr. Sargent came to Providence, formed the Rice & Sargent Engine Co. and began the building of Rice & Sargent engines. Later the business was conducted as the Providence Steam Engine Co. and later still as the Providence Engineering Works. During the last few years he has devoted himself to research work upon problems connected with prime movers.

Mr. Sargent was a member of the A.S.M.E. and the Providence Engineering Society and an honorary member of the Rhode Island No. 1, N.A.S.E.

New Publications

"Mechanical World" Electrical Pocket Book, 1923. Published by Emmott & Co., Ltd., *"Mechanical World"* Office, 65 King St., Manchester, England. Cloth, 4 x 6 in., 389 pages, including advertisements. Price, 1s. 6d.

Among the new features of this issue is a section on plant, load and diversity factors. Another new section is devoted to electrical measuring instruments. Comprising a collection of electrical engineering notes, rules, tables and data, this handbook also contains useful tables of postoffice regulations and foreign money, weights and measures, written, of course, from the British point of view.

Personal Mention

Fred L. Yelton has left the Presidio Mining and Milling Co., where he was assistant master mechanic, to become chief power-plant engineer of the Empire Zinc Co., Hanover, N. M.

Julian C. Smith has been appointed president of the new St. Maurice Power Co., Shawinigan Falls, Que. He is still consulting engineer of the Manitoba Power Co.

John S. Carpenter, formerly assistant hydraulic turbine engineer with the Worthington Pump & Machinery Corp., Harrison, N. J., is now with the S. Morgan Smith Co., of York, Pa., builders of hydraulic turbines and their accessories.

Society Affairs

Buffalo Section, A.S.M.E., will hear W. H. Carrier, of the Carrier Engineering Corp., on "Air Conditioning and Ventilation," at its meeting on Feb. 21 at the Iroquois Hotel.

Detroit Section, A. S. M. E. will hear two papers on Feb. 23 at the Board of Commerce: "Tests of Type W Stirling Boilers" (illustrated), by P. W. Thompson, of the Detroit Edison Co., and "Elasticity of Pipe Bends," by Sabin Crocker and S. S. Sanford, also of the Detroit Edison Co.

Business Notes

The Conveyors Corp. of America, 326 West Madison St., Chicago, has acquired all rights to the Green Steam Jet Ash Conveyor from the Green Engineering Co., East Chicago, Ind.

The Bussmann Manufacturing Co., St. Louis, has opened an office in the Philadelphia Bourse, Philadelphia, with A. E. Arthurs as district manager. Mr. Arthurs, formerly district manager at Pittsburgh, is succeeded in that territory by R. C. McDaniels.

The Open Coil Heater & Purifier Co., Indianapolis, Ind., has changed its name to **Stickle Steam Specialties Co.** Cole Stickle is president.

The Gifford-Wood Co., Hudson, N. Y., has promoted Joseph A. Boucher to the position of sales manager. Mr. Boucher has been with the company more than fifteen years.

The French-Gerleman Electric Co., 108-110 South Tenth St., St. Louis, Mo., has been formed by a merger of the French Electric Co. and the Electrical Machinery and Specialty Co. There has been no change in management or location; the electrical motor and repair business of the two former companies will be continued. A. O. French is president; J. F. Gerleman, vice-president, Charles C. French, secretary, and A. E. French, treasurer.

Coming Meetings

National Association of Stationary Engineers; Fred W. Raven, 417 South Dearborn St., Chicago, Ill. Annual conventions and exhibitions of the State Associations scheduled as follows:

Kansas, at Fort Scott, Apr. 4-6; C. H. Taylor, 517½ W. 6th St., Topeka.

American Society of Mechanical Engineers, 29 W. 39th St., New York City. Pacific coast regional meeting at Los Angeles, Apr. 16-18; spring meeting at Montreal, Canada, May 28-31.

Society of Industrial Engineers; George C. Dent, 327 S. La Salle St., Chicago, Ill. Spring convention at Cincinnati, Ohio, Apr. 18-20.

American Welding Society, 29 W. 39th St., New York City. Annual meeting at New York City, April 27-28.

American Association of Engineers, 63 East Adams St., Chicago, Ill. Annual convention at Norfolk, Va., May 7-9.

American Water Works Association, 153 W. 71st St., New York City. Annual meeting at Detroit, Mich., May 21-25.

National Electric Light Association; M. H. Aylesworth, 29 West 39th St., New York City. Annual meeting at New York City, June 4-8.

Electric Power Club; S. N. Clarkson, Kirby Bldg., Cleveland, Ohio. Annual meeting at Hot Springs, Va., June 11-14.

American Institute of Electrical Engineers, 29 W. 39th St., New York City. Annual convention at Swampscott, Mass., June 25-29.

American Society for Testing Materials; C. L. Warwick, 1315 Spruce St., Philadelphia, Pa. Annual meeting at Atlantic City, N. J., June 25-30.

Trade Catalogs

Boiler Accessories — Heine Safety Boiler Co., 5319 Marcus Ave., St. Louis, Mo. Pamphlet describing special fire-clay tile, door jamb and arch, cast-iron plates, wall liners, firedoor liner, grate bar, handhole plate and yoke and special tools.

Centrifugal Pumps — Allis-Chalmers Co., Milwaukee, Wis. The January issue of "Centrifugal Pump Users' Guide," giving the size, type, horsepower, and speed of centrifugal pumping units. These data are conveniently tabulated, with columns showing the number of units in stock for both d.c. and a.c. motor drive of different voltages.

Small Centrifugal Pumps—De Laval Steam Turbine Co., Trenton, N. J. Bulletin and instruction manual describing small single-stage centrifugal pumps for motor or belt drive, made in 1½- and 2-in. sizes and designed for capacities ranging from 5 gal. per min. against a 10-ft. head up to 130 gal. per min. against a 150-ft. head. Complete tables for selecting pumps for different conditions are included.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Feb. 5 1923	Feb. 12 1923
Pool 1,	New York	$5.00–5.75	$5.00–5.50
Smokeless,	Columbus	5.00–6.00	4.50–5.00
Clearfield,	Boston	3.50–4.25	3.50–4.25
Somerset,	Boston	3.60–4.25	3.75–4.50
Kanawha,	Columbus	3.00–3.35	2.50–2.75
Hocking,	Columbus	2.65–3.00	2.40–2.65
Pittsburgh No. 8	Cleveland		3.15–3.20
Franklin, Ill.,	Chicago	3.75–4.00	3.75–4.00
Central, Ill.,	Chicago	2.75–3.00	2.50–2.75
Ind 4th Vein,	Chicago	3.00–3.25	3.00–3.25
West Ky.,	Louisville	2.25–2.50	2.25–2.50
S. E. Ky,	Louisville	3.00–3.50	2.25–3.00
Big Seam,	Birmingham	2.25–2.50	2.25–2.50

FUEL OIL

(f.o.b. city unless otherwise specified)

New York—Feb. 1, Port Arthur light oil, 22@25 deg. Baumé, 4¾c. per gal.; 30@35 deg., 5¼c. per gal., f.o.b. Bayonne, N. J.

Chicago—Feb. 6, for 24@26 deg. Baumé, $2.02 per bbl.; 32@36 deg., $5.56 per bbl. in tank car.

Philadelphia — Feb. 5, 26@28 deg. Baumé, Oklahoma, $1@$1.05 per bbl. 30@34 deg., Oklahoma (group 3), 3@3¼c. per gal.; 16@20 deg. Seaboard, $1@$1.05 per bbl.

St. Louis—Feb. 12, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.90 per bbl.; 26@28 deg., $1.95; 28@30 deg., $2; 30@36 deg., $2.15 per bbl. gas oil; 36@40 deg., $2.25 per bbl. distillate.

Pittsburgh—Jan. 9 f.o.b., refinery, Penn., 36@40 deg., 5½@5¾c. per gal.; Kentucky, 26@30 deg., 4c.; Gas Oil, 32@36 deg., 2¼@2¾c.; 36@38 deg., 2½@3c.; 38@40 deg., 90c.@$1.05 per bbl.

Dallas — Feb. 3, 26@30 deg., $1.28 per bbl.

New Plant Construction

PROPOSED WORK

Ala., Haleyville—The town plans the construction of an electric light plant. Prices wanted on machinery and equipment for same.

Calif., Los Angeles — J. C. Austin, Archt., Baker-Detwiler Bldg., is receiving bids for the construction of an 8 story office building on 11th St., for the Los Angeles Chamber of Commerce, Chamber of Commerce Bldg. Equipment detail not reported.

Calif., Orland — The Orland Cheese & Butter Co., J. N. Cook, Secy., plans to build an addition to its ice plant and additional quarters for storage.

Calif., Pasadena — R. S. McClelland is having plans prepared for the construction of an ice plant on Cordova and Vermont Sts. Cost will exceed $50,000. A. G. Bailey, Junior Orpheum Bldg., Los Angeles, Archt.

Calif., Sacramento—The city is having plans prepared for the Silver Creek municipal power project, including dam, tunnels and 3 power plants to generate approximately 150,000 hp. Cost will exceed $5,000,000. A. Givan, City Engr.

Calif., San Francisco — The city and county will soon award the contract for furnishing, delivering and erecting structural steel for a 75 x 230 ft. Moccasin Creek hydro-electric power plant of Hetch Hetchy project, about 26 miles from Oakdale.

Calif., Wilmington — The Pacific Coast Borax Co., Central Bldg., Los Angeles, is having plans prepared for the construction of factory buildings to include a 2 story, 250 x 450 ft. main building, power plant and a 900 ft. wharf. Estimated cost $1,000,000. A. C. Martin, Higgins Bldg., Los Angeles, Archt.

Colo., Calhan—The city is having plans prepared for the construction of an electric light plant and waterworks system. Estimated cost $50,000. Brew & Sidow Eng. Co., 210 Kittridge Bldg., Denver, Engrs.

Colo., Denver — The United States Reclamation Service, A. P. Davis, Dir., will receive bids until March 13 for furnishing one hydraulic turbine with synchronous bypass valve, one 1,000 kva. generator, transformers and switching apparatus for the Pilot Butte power plant, Riverton project, Wyo.

Conn., New Britain—The State Bd. Educ., A. R. Meredith, Secy., State Capitol, Hartford, plans the construction of 3 story dormitory at the State Normal School, here. Estimated cost $500,000. Architect not selected.

Ill., Chicago—The Commonwealth Edison Co., Adams and Clark Sts., is having plans prepared for the construction of a 4 story, 118 x 211 ft. first unit of its central station on Crawford Ave. Estimated cost $10,000,000. Sargent & Lundy, 89 West Adams St., Mechanical Engrs. Graham, Anderson, Probst & White, 80 East Jackson St. Archts.

Ill., Chicago — The Creamery Package Mfg. Co., 61 West Kinzie Ave., is in the market for a large size air compressor.

Ill., Chicago—The G. E. Corbett Boiler & Tank Co., 1332 Cortland St., is in the market for a 300 cu.ft. air compressor.

Ill., Chicago—E. Ketzinger & Co., 910 West Washington Blvd., manufacturer of utensils, tools and machinery, is having plans prepared for the construction of a 2 story factory, to contain 200,000 sq.ft. of floor space, including steam heating system, on Armitage and Cicero Sts. Estimated cost $1,000,000. A. S. Alschuler, 28 East Jackson Blvd., Archt.

Ind., Hammond—The First Natl. Bank plans the construction of an 8 story bank and office building on Hohman St. Estimated cost $500,000. Engineer or architect not selected.

Ia., Des Moines—The School Bd., G. L. Garton, Secy., plans election Mar. 12, to vote $2,630,000 bonds for the construction of new school buildings and additions.

Ia., Waterloo—The Paul Davis Dry Goods Co., 510 Commercial St., is having plans prepared for the construction of a 6 to 8 story store building, including steam heating system. Estimated cost $600,000. C. P. Shockley, 719 Black Bldg., Archts.

Kan., Coffeyville—H. Powell will have plans prepared for the construction of a 5 story, 100 x 140 ft. hotel. Estimated cost $300,000. Shephard & Wiser, 302 R. A. Long Bldg., Kansas City, Archts. Equipment detail not reported.

Kan., Fredonia—The city will hold an election Feb. 27 to vote on a $150,000 bond issue for the construction of an electric lighting plant. C. H. Schiek, Engr.

Kan., Hays — The Capauchin Fathers, Concordia, are having plans prepared for the construction of 4 school buildings, here. Estimated cost $1,000,000. C. A. Smith, 109½ Santa Fe Ave., Salina, Archt. Equipment detail not reported.

Kan., Kansas City—B.P.O.E. Lodge No. 440, W. L. Woods, Secy., 717 Minnesota Ave., is having plans prepared for the construction of a 12 story club and office building on 7th and Minnesota Aves. Estimated cost $700,000. J. T. Craven Eng. Co., St. Louis, Mo., Archts. Equipment detail not reported.

Kan., Topeka—Christ Hospital, 10th and West St., has had preliminary plans prepared for the construction of a 4 story hospital. Estimated cost $500,000. Garden & Martin, 104 Michigan Ave., Chicago, Archts. Equipment detail not reported.

Ky., Lexington—The city voted $500,000 bonds for the construction of a new city hall building on North Timestone and Barr Sts. F. L. Packard, Hayden Bldg., Columbus, Ohio, Archt.

Ky., Louisville—The Consolidated Realty Co., 229 South 5th St., plans the construction of an addition to the Puritan Apartments on 4th St. near Ormsby Ave. Estimated cost $800,000.

La., DeQuincy—The city, W. W. Tuck, Pres. Municipal Water Works, Light and Power Plant Bd., will receive bids until Mar. 6, for constructing and furnishing materials for electric light and water works system, including furnishing and installing 50 kw. and 100 kw. 80% P.F., 2,300 volt, 3 phase, 50 cycle, a.c. generators direct connected to oil engines; switchboard; motor driven fire pump; reinforced concrete reservoir; steel tank and tower; oil storage tank and well; motor driven well pump; cast iron and galvanized iron water distributing system; electric light and power distributing system; water meters; electric meters; transformers. J. W. Billingsley, 711 Interstate Bank Bldg., New Orleans, Consult. Engr. Noted Jan. 16.

Md., Baltimore—J. L. Barr, Consulting Engr., 224 St. Paul Pl., is in the market for one or two 50 ton refrigerating machines, belt or motor driven, a.c. 220 volt, 3 phase, 60 cycles; also condensers for 100 ton capacity ice making receivers, etc., standard make (used).

Md., Baltimore—The Home Friendly Society, G. A. Chase, Pres., 1026 Linden Ave., is having plans prepared for the construction of a 10 story, 60 x 150 ft. office building on Park Ave. and Centre St. Estimated cost $500,000. H. F. Doeleman, 507 North Charles St., Engr. C. N. and N. Friz, Lexington Bldg., Archts. Equipment detail not reported.

Mass., Northampton—The Plymouth Inn Association is having plans prepared for the construction of a 7 story addition to its hotel, to contain 126 rooms, connected by a 1 story addition, on West St. Estimated cost $560,000. Mowll & Rand, 21 School St., Boston, Archts. Equipment detail not reported.

Mass., Salem—P. A. Sweeney et al., 246 Essex St., plans to build a 4 story cold storage plant. Estimated cost $150,000. Engineer or architect not announced.

Mich., Bay City—The Water Comm. will receive bids until March 5 for electric and power wiring, heating, ventilating and furnishing filter equipment for water works plant. Estimated cost $150,000. The owner is also in the market for two or three low life centrifugal pumps, total of 15,000,000 gal. capacity. Frazier, Sheal & Ellms, B. F. Keith Bldg., Cleveland, Ohio, Engrs.

Mich., Detroit — J. M. Robertson, Book Bldg., plans the construction of a 2 story, 140 x 160 ft. theatre, including steam heating equipment, vapor system, on Gratiot Ave. and May St. Estimated cost $500,000. C. W. Brandt, Kresge Bldg., Archt.

Mich., Mottville — G. W. Hamilton, 72 West Adams St., Chicago, Ill., will receive bids from about Feb. 20th to March 6th for the construction of a 30 x 60 x 140 ft. hydro-electric plant, 2200 kva. capacity, on the St. Joseph River, here, including four 550 hp. hydro electric turbines, 4 waterwheels, water level dam 11 ft. 6 in. high, 250 ft. long with flood gates on crest, for the Middle West Utilities Co., 72 West Adams St., Chicago, Ill., and the Michigan Gas & Electric Co., Three Rivers, Mich., joint owners. Estimated cost $400,000. Holland, Ackerman & Holland, 53 West Jackson St., Chicago, Ill., Engrs. Noted Dec. 7, 1922.

Minn., Minneapolis—The Bd. Educ., 305 City Hall, G. F. Womrath, Business Supt., will receive bids until Feb. 23 for the construction of a 3 story, 45 x 250 x 300 ft. Junior High School, with one 1 story, 60 x 80 ft. wing, including steam heating system, on 26th St. and Emerson Ave. S. Estimated cost $550,000. Bureau of Bldgs., Engr. Division of Design & Inspection, Bd. Educ., 245 9th Ave., Archt. Noted Oct. 31.

Minn., St. Cloud—The U. S. Veterans' Bureau, Wash., D. C., is having plans prepared for the construction of a group of 2 and 3 story hospital buildings here. Estimated cost $3,000,000. A. H. Stem, 601 Endicott Bldg., St. Paul, Archt. Equipment detail not reported. Noted Sept. 19, 1922.

Minn., St. Paul—The Department of Educ., L. R. S. Ferguson, Comr., City Hall, is having plans prepared for the construction of two 3 story senior high schools, including chemical laboratories and shops, one in Rice St. district and the other in Dayton district; also for four 3 story junior high schools in Macalester district, near Victoria St. and Marshall Ave., at Walsh Ave. and Jenks St., at Baldwin Ave. and at Grand St. The latter is for remodeling. Estimated cost $600,000 and $400,000 respectively. F. X. Tewes, City Hall, City Archt. Equipment detail not reported.

Minn., St. Paul—The Northwest Baptist Hospital Assn., R. Earl, Chn. Bd. of Dirs., 1210 Lowry Bldg., plans to build a 3 or 4 story hospital, including steam heating system, on University and St. Anthony Aves. Estimated cost $400,000. Engineer or architect not announced.

Mo., Hayti—The city will receive bids until March 2, for 2 internal combustion engines of approximately 100 hp. direct connected to 3 phase, 60 cycle, 2,300 volt generators, switchboards and wiring. C. W. Moore, 222 Independence Bldg., Joplin, Engr.

Mo., Kirksville—The city will hold an election Feb. 24 to vote on a $200,000 bond issue for improvements to waterworks system, including pumps, filtration plant, tank and tower, also electric plant and transmission line. Black & Veatch, 701 Mutual Bldg., Kansas City, Engrs. Noted Feb. 6.

Mo., St. Louis—The city voted $1,000,000 bonds for power and service building, including machine shop, garage and laundry for municipal requirements, $8,000,000 for street lighting equipment; $5,100,000 for Missouri River plant, including pumping station, pumps, etc., $1,997,500 for conduits and right-of-way, $1,150,000 for reservoir, $2,740,000 for distributing mains, $1,032,500 for contingencies; $5,000,000 for auditorium and community center, $4,500,000 for additions to hospitals, $4,000,000 for new court house and site, and $1,250,000 for reconstruction of public market.

Mo., St. Louis—The McKinley Traction System, Peoria, Ill., is having plans prepared for the construction of a 14 story, 75 x 135 ft. office building on 12th St. and Boulevard. Estimated cost $1,000,000. Engineer or architect not announced.

Mo., St. Louis—J. Siebens, 2802 Olive St., is in the market for a 1,000 volt, 400 watt generator.

Neb., Omaha—C. A. & R. C. Cook, c/o George & Co., 902 City Natl. Bank Bldg., plans the construction of a 3 story store and office building. Estimated cost $1,000,000. Private plans.

N. Y., Brooklyn—The Kenmore Trading Corp., c/o W. T. McCarthy, Engr. and Archt., 159 Remsen St., is having plans prepared for the construction of a 178 x 222 ft. apartment house on Kenmore Pl. and Caton Ave. Estimated cost $1,000,000. Equipment detail not reported.

N. Y., Buffalo—The Dept. Parks & Bldgs., J. Meahl, Comr., is having preliminary plans prepared for the construction of a Natural Science Museum on Humbolt Pkway. Estimated cost $1,000,000. Essenwein & Johnson, Ellicott Sq. Bldg., Archts.

N. Y., Gouverneur — The Oswegatchie Light & Power Co., J. J. Wallace, Supt.,

is in the market for a 600 hp. engine with oil burning boiler.

N. Y., Jamestown—The Jamestown Chair Co., 20 Winsor St., is in the market for complete equipment for power and boiler house. Estimated cost $25,000.

N. Y., New York—Weber & Fields, c/o C. C. Weber & Co., Engrs. and Archts., 3rd and Walnut Sts., Cincinnati, Ohio, are having preliminary plans prepared for the construction of a theatre on West 43rd St., here. Estimated cost $2,000,000.

N. Y., Watertown—The city will hold an election Feb. 24 to vote on a $365,000 bond issue to develop municipal power at Delano Falls. J. W. Ackerman, City Mgr. Noted Mar. 14.

O., Akron—Bd. Educ., 102 South Union St., is having plans prepared for the construction of a school building on Brown and Archwood Sts. Estimated cost $800,000. M. M. Konarski, 102 South Union St., Archt. Equipment detail not reported.

Ohio, Cincinnati — The Cincinnati Terminal Warehouse Co., W. E. Fox, Mgr., will soon award the contract for the construction of a 7 story, 175 x 600 ft. terminal warehouse on Front and Central Aves. Estimated cost $2,000,000. A. M. Allen & Co., 7016 Euclid Ave., Cleveland, Engrs. and Archts. Noted May 9.

O., Cleveland—The Brownell Bldg. Co., c/o S. Kaplan, jeweler, 1418 Prospect Ave., plans to build a 10 or 11 story, 140 x 148 ft. hotel, including steam heating system, on East 14th St. and Prospect Ave. Estimated cost $1,500,000. Engineer or architect not selected.

O., Cleveland—The city, c/o Comr. of Supplies, is in the market for two 200 kw. steam turbine generators, one air compressor and three centrifugal motor driven vacuum pumps.

Ohio, Cleveland—The Cleveland Electric Illuminating Co., C. L. Stone, Asst. Genl. Mgr., 74 Public Sq., is having plans prepared for the construction of an electric boosting station on North Woodward Rd. and 130th St. Estimated cost $50,000. Private plans.

Ohio, Cleveland—The W. S. Tyler Co., C. Zimmerman, Pres., 3615 Superior Ave., is having plans prepared for the construction of a 3 or 4 story factory at 3803 Superior Ave. Estimated cost $500,000. G. S. Rider & Co., Century Bldg., Archts.

O., Cleveland—The Cuyahoga County Council of the American Legion, c/o L. P. Wolford, Secy., East 21st St. and Euclid Ave., is having plans prepared for the construction of a 13 story club and office building. Estimated cost $900,000. Engineer or architect not announced. Noted Apr. 11.

Ohio, Cleveland Heights, (Warrensville P. O.)—B'nai Jeshurun Congregation, c/o H. Spira, 2207 Ontario St., Cleveland, is having sketches made for the construction of, 3 story temple, including steam heating system on Euclid Heights and Derbyshire Rd. Estimated cost $750,000. J. L. Weinberg, 3226 Euclid Ave., Cleveland, Archt.

Ohio, Dayton — The Bd. Educ., C. S. Schmidt, Clk., plans the construction of a 2 story school building on Burns Ave. Estimated cost $500,000. E. E. Turvene, c/o Bd. Educ., Archt.

Ohio, Dayton—The city, F. O. Eichelberger, Mgr., plans the construction of an 8 story, 50 x 300 ft. municipal office building on Main and Market Sts. Estimated cost $750,000. Engineer or architect not selected.

O., East Cleveland (Cleveland P. O.)—The Bd. Educ., C. B. Tilden, Dir., has had preliminary plans prepared and will hold an election Feb. 27 to vote on a bond issue for the construction of a 3 story high school, including steam heating system, on Euclid and Grasmere Aves. Estimated cost $750,000. Cavanaugh & Baer, 2725 Prospect Ave., Cleveland, Archts.

Ore., Astoria — The Union Oil Co. of California, Yeon Bldg., Portland, is having plans prepared for the construction of a 300 x 350 ft. dock, oil tanks, pumping plant, pipe lines, tracks and small buildings. Bids will be received in about 60 days for dock, filling and grading, balance of work will be done under supervision of company engineers. Estimated cost $500,000. Private plans.

Pa., Altoona—F. A. Lind, 2002 5th Ave., is in the market for an electric motor, 10 hp. a.c. or larger.

Pa., Meshoppen—The Meshoppen Light Co. plans to rebuild portion of its light and power plant, destroyed by fire. Owner is in the market for new power equipment.

Pa., Mt. Pleasant—The Mt. Pleasant Ice Co. plans rebuilding of portion of its ice mfg. plant destroyed by fire. Estimated cost $25,000.

R. I., Central Falls — The Notre Dame Hospital, c/o Franco-American Society of Rhode Island, C. H. Bouchee, Broad St., member of Hospital Comn., plans to build a 3 story hospital on Hunt and Broad Sts. Estimated cost $250,000. Engineer or architect not announced.

S. C., Columbia—The Ryan Eng. Co., Arcade Bldg., is in the market for a 1 engine generator set, 150 kva. capacity (new or used).

S. D., Leola—The Herald is in the market for a 110 volt standard alternating current motor.

Tenn., Chattanooga — The South Steel Co., James Bldg., is having tentative plans prepared and will soon receive bids for the construction of a steel plant, to cover 30 acre tract, the first unit will be 2 open hearth furnaces, capacity 60,000 tons annually. Estimated cost $600,000. 8 set rolling mills to have capacity of 5,500 tons annually will be built later. Estimated cost $900,000. Sleeper Eng. Co., Pittsburgh, Pa., Engrs.

Tex., Dallas—The Jates Laundry Co. is in the market for 100 hp. high pressure boiler.

Tex., Fort Stockton — The city, J. M. Rooney, mayor, will receive bids until March 8 for waterworks improvements, including materials, appliances and installation of cast iron pipe, pumps, construction of pump houses, concrete ground storage reservoir and tank foundations, furnishing and erecting 75,000 gal. steel tank and tower. Terrell & Bartlett, 612 Calcasieu Bldg., San Antonio, Consult. Engrs.

Tex., Leonard—The Leonard Ice & Light Co. is in the market for a 100 hp. vertical oil engine with 90 kva. generator.

Va., Winchester—H. C. Greathorn is in the market for a 16 hp. steam engine.

W. Va., Dryrun—G. Calhoun is in the market for a 20 hp. traction steam engine (used).

Wis., Shorewood (Milwuakee P. O.)—The village, T. B. Olsen, Clk., is having plans prepared for electric lighting distribution system, to replace present gas system. Estimated cost $75,000. A. J. Sweet, 531 Grand Ave., Milwaukee, Engr. Noted Nov. 28.

Wis., Waunakee—The Waunakee Canning Co., A. P. Kenney, Pres., is having plans prepared for the construction of a 2 story, 60 x 95 ft. canning factory. Estimated cost $100,000. Balch & Lippert, Gay Bldg., Madison, Archt. The owner is in the market for power and canning machinery. Noted Jan. 2.

Canada—The Canadian Pacific Ry., Windsor St. Sta., Montreal, Que., plans a program of construction during the coming year, including shop improvements at Weston, Ont.; Reston and Minnedosa, Man.; Regina, Broadview and Neudorf, Sask.; Calgary, Alta.; improvements in refrigeration facilities at Brandon and Winnepeg, Man.; Sutherland, Sask.; terminal office building at Victoria, B. C.; coal plant extensions at Fort William, Ont.

Ont., Thorold—The Utilities Comn., J. F. Wilson, Chn., is in the market for a switchboard generator and transformer for central station.

Ont., Toronto—The city plans to install a 25,000,000 Imp. gal. pump, three stage electric or steam driven, at the High Level Waterworks Pumping Station. Estimated cost $150,945. R. C. Harris, City Hall, Engr.

Ont., Toronto—The city plans the construction of a pumping station, including steam power plant for operating pumps, at Riverdale, in connection with waterworks program. Estimated cost $200,000. R. C. Harris, City Hall, Engr. Noted Aug. 29.

CONTRACTS AWARDED

Calif., Glendale — The Glendale High School District awarded the contract for the construction of a high school consisting of 2 buildings, to the North-Pacific Constr. Co., Baker-Detwiler Bldg., Los Angles. Estimated cost $457,865. Contract for heating, ventilating, electric work, etc. will be awarded later. Noted Jan. 23.

Calif., Hollywood (Los Angeles P. O.)—The Hollywood Hospital Assn. awarded the contract for the construction of a 5 story hospital on Vermont and Sunset Sts. to the J. Simpson Co., 701 Antonio St., Los Angeles. $273,235. Contracts for plumbing, heating and electric work will be awarded later. Noted Jan. 2.

Calif., Mountain View — The Roman Catholic Archbishop of San Francisco, 1100 Franklin St., awarded the contract for the construction of 4 story college buildings for St. Joseph College, here, to J. L. McLaughlin, 251 Kearny St., San Francisco. Estimated cost $2,250,000. Equipment detail not reported. Noted June 13.

Calif., Sacramento—The Consumers Ice & Cold Storage Co., 8th and D Sts., awarded the contract for the construction of an addition to its ice plant to D. R. Wagner, Call Bldg., San Francisco. Estimated cost $40,700. The contract for equipment was awarded to the Gay Engr Co., 336 California St., San Francisco.

Ia., Van Horn—The city awarded the contract for the construction of a new waterworks system, including pump house and deep well pumping equipment, capacity 77 g.m.p. against 300 ft. head and 10 hp. kerosene engine, to the Des Moines Steel Co., South 5th and Tuttle Sts., Des Moines. $29,200. Noted Dec. 26, 1922.

Mich., Detroit—L. Schmeid, 12541 Hamilton Blvd., awarded the contract for the construction of a 3 story apartment building to contain 65 apartments, including steam heating plant, boiler and equipment, on Hamilton Blvd., to S. E. Benjamin & Co., 9825 Greeley Ave., Detroit. Estimated cost $300,000.

Minn., Minneapolis—J. H. Davidson, 723 Plymouth Bldg., awarded the general contract for the construction of group of five 3 story apartment buildings on Lake Calhoun Blvd., to the Fleisher Constr. Co., 100 Builders' Exch. Engineer's estimate, $1,375,000. Steam heating system will be installed.

Minn., Minneapolis—The Nicollet Hotel Corp., 520 First Natl.-Soo Line Bldg., A. E. Zonne, Chn. Bldg. Comn., awarded the contract for the construction of a 10 story hotel, including steam heating system, on Washington and Hennepin Aves., to C. F. Haglin & Sons Co., 226 Lumber Exch., Minneapolis. Estimated cost $3,000,000.

Mo., St. Louis—The St. Mary's Hospital, 1536 Papin St., awarded the contract for the construction of a 7 story hospital on Clayton Rd. and Pennsylvania Ave. to the Raterman Bldg. and Constr. Co., 1943 St. Louis Ave., St. Louis. Estimated cost $400,000. Equipment detail not reported. Noted Sept. 20, 1921.

N. J., Trenton—The Bahrenberg Ice Co., 51 Tucker St., awarded the contract for the construction of a 2 story, 60 x 70 ft. ice manufacturing plant to the J. H. Morris Co., 211 North Montgomery St., Trenton. Estimated cost $11,500.

N. J., Trenton—The Bd. Educ., R. Belville, Secy., 9 South Stockton St., awarded the general contract for the construction of Junior High School No. 3, to C. J. Smith Constr. Co., 202 Academy St., Trenton, $778,000; heating and ventilating to E. G. Woolfolk & Co., 17 West 38th St., Phila., Pa., $98,464; plumbing to N. Connolly, 1404 North 18th St., Phila., Pa., $51,192; electrical work to A. W. Bensel, Virginia Ave., Atlantic City, $27,514. Noted Jan. 30.

N. Y., New York—The Y.M.C.A., 2 West 45th St., awarded the contract for the construction of a 20 story Y.M.C.A. building to the G. A. Fuller Co., 175 5th Ave., New York. Estimated cost $1,200,000. Equipment detail not reported. Noted July 4.

N. Y., Saranac Lake—The Chamber of Commerce awarded the contract for the construction of a 157 room hotel on Main and River Sts., to the J. G. White Eng. Corp., 43 Exch. Pl., New York. Estimated cost $400,000.

O., Cleveland—The Ohio Provision Co., Clark Ave. along tracks of Cleveland, Cincinnati, Chicago and St. Louis Ry., J. B. McCrea, Pres., awarded the contract for the construction of a 1 story, 25 x 126 cooler building to the W. I. Thompson & Son Co., 5103 Euclid Ave., Cleveland. Estimated cost $40,000.

Pa., Phila.— The 15th and Chestnut Sts. Realty Co., c/o M. B. Saul, Land Title Bldg., awarded the contract for the construction of a 24 story, 72 x 230 ft. bank and office building, including steam heating system, on 15th and Chestnut Sts. to the Thompson-Starrett Co., 49 Wall St., New York. Estimated cost $3,000,000. Noted Nov. 21.

Pa., Phila.—T. H. Hargest, 501 North 52nd St., awarded the contract for the construction of a 6 story, 208 x 214 ft. apartment house on 46th and Walnut Sts. to the J. R. Wiggins Co., 18th and Cherry Sts., Phila. Estimated cost $900,000. Equipment detail not reported. Noted Apr. 11.

Wis., Fort Atkinson—The Fort Atkinson Canning Co. awarded the contract for the construction of a canning plant, to the T. S. Willis Co., 330 Hayes Blk., Janesville, Wis. Estimated cost $150,000. Owner is receiving bids on 3 power boilers, heating, electrical work and plumbing. Noted Jan. 30.

B. C., Powell River—The Powell River Co., Ltd., awarded the contract for the construction of 65 x 130 ft. steam plant, to replace existing plant supplying steam to paper mills, including six 500 hp. Babcock Wilcox boilers, to C. C. Moore, 1125 Standard Bank Bldg., Vancouver. Estimated cost $200,000. Owner is also considering raising their dam and putting in two new electrical units.